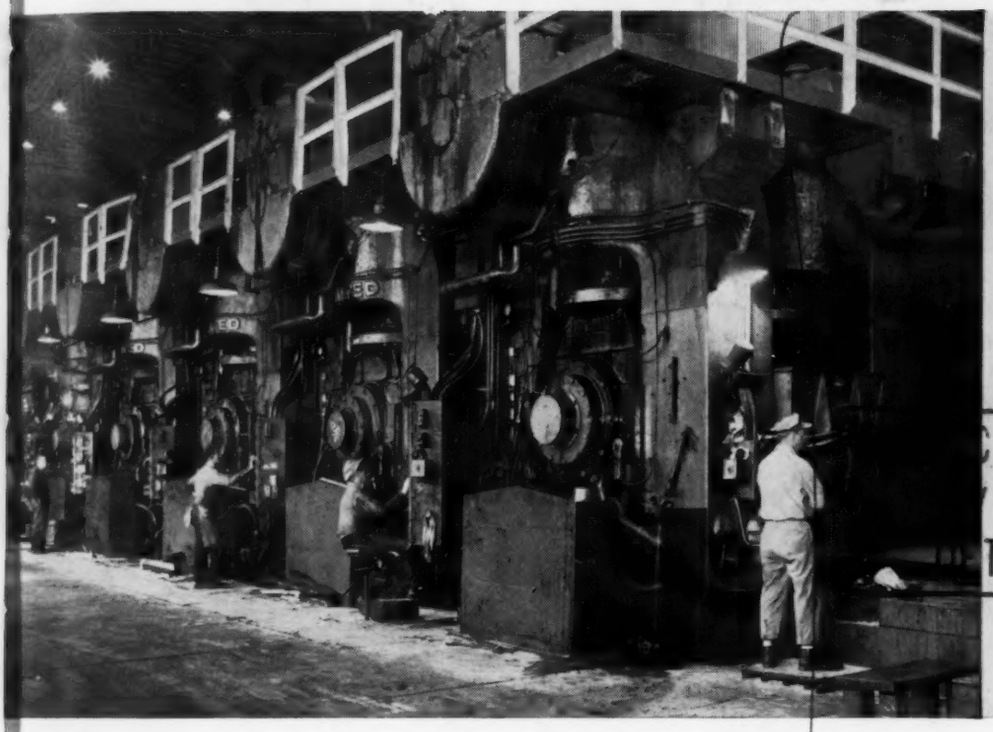
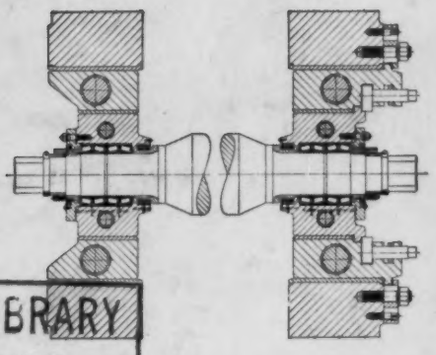
Iron and Steel ENGINEER

ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

TECHNOLOGY DEPARTMENT

NOVEMBER, 1959





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UNITED ENGINEERING mounts the work roll necks on the 4-high cold rolling mill on Timken tapered roller bearings to give lower cost per ton of steel rolled.

How Weirton cold rolls steel up to 5,000 F.P.M.

COLD rolling steel up to 5,000 F.P.M. calls for bearings with real guts. That's why United Engineering specified Timken® tapered roller bearings on the work roll necks of this 4-high tandem cold mill built for Weirton Steel Company, Division of National Steel Corporation. And to maintain gage and quality at these high speeds, they specified Timken bearings on the mill gear drives and pinion stands, tension reel, payoff reel screwdown drive, the coil transfer car, coil rotating rig and for the tilting gear drive for the coil unloader.

Timken tapered roller bearings have the high radial and thrust capacity you need for modern steel mills. They're tapered to take any combination of radial and thrust loads. And they're case-carburized to produce hard, wear-resistant surfaces over tough, shock-resistant cores. Both are reasons why Timken bearings have records in steel mills the world over.

Because Timken bearings practically eliminate friction, cut starting resistance, they cut scrap losses to a bare minimum. Grease lubricated, they cut maintenance costs to the bone. It all adds up to lower bearing cost per ton of steel rolled... why Timken tapered roller bearings are on the roll necks of 1,008 mills.

Specify Timken tapered roller bearings for the next rolling mill you buy or build. They make good machines better, help turn out a better product for less money. And with Timken bearings you get the best engineering service there is. That's Better-ness. And Timken bearings are the symbol of Better-ness. The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

This symbol on a product means its bearings are the best.

BETTER-ness rolls on **TIMKEN®** tapered roller bearings

Cutler-Hammer 505 Mill Brakes

now in seven sizes . . .
first complete line to meet the latest AISE-NEMA Standards

These are the features that have made the Cutler-Hammer 505 Mill Brake the choice of Mill Engineers everywhere. Compare it . . . test it . . . prove it. The 505 Mill Brake is built better to last far longer.

Only ten major components; the ultimate in design simplicity . . . avoids the clutter and trouble of complex linkage systems.

Over-the-wheel pull rod provides a one-to-one leverage ratio; reduces the lower bearing pressure by absorbing half the braking force.

Single, weatherproof operating coil easily accessible and reversible. Leads can be brought out in either direction.

Shoe clearance can be adjusted even in total darkness. No dials to read, no sticking gauges, no complicated mechanisms to maintain.

All adjustments made with an ordinary wrench, and all nuts are above the motor shaft for easy access.

No lubrication required. Oversize bearings have extremely low pressures; can't stick or bind.

Compact rectifier panels bring all the plus features of the rugged 505 Mill Brake to jobs where only A/C power is available.

Get all the facts before you decide. Write today for detailed description and data. Bul. 505-W232 Cutler-Hammer Inc., Milwaukee 1, Wisconsin.

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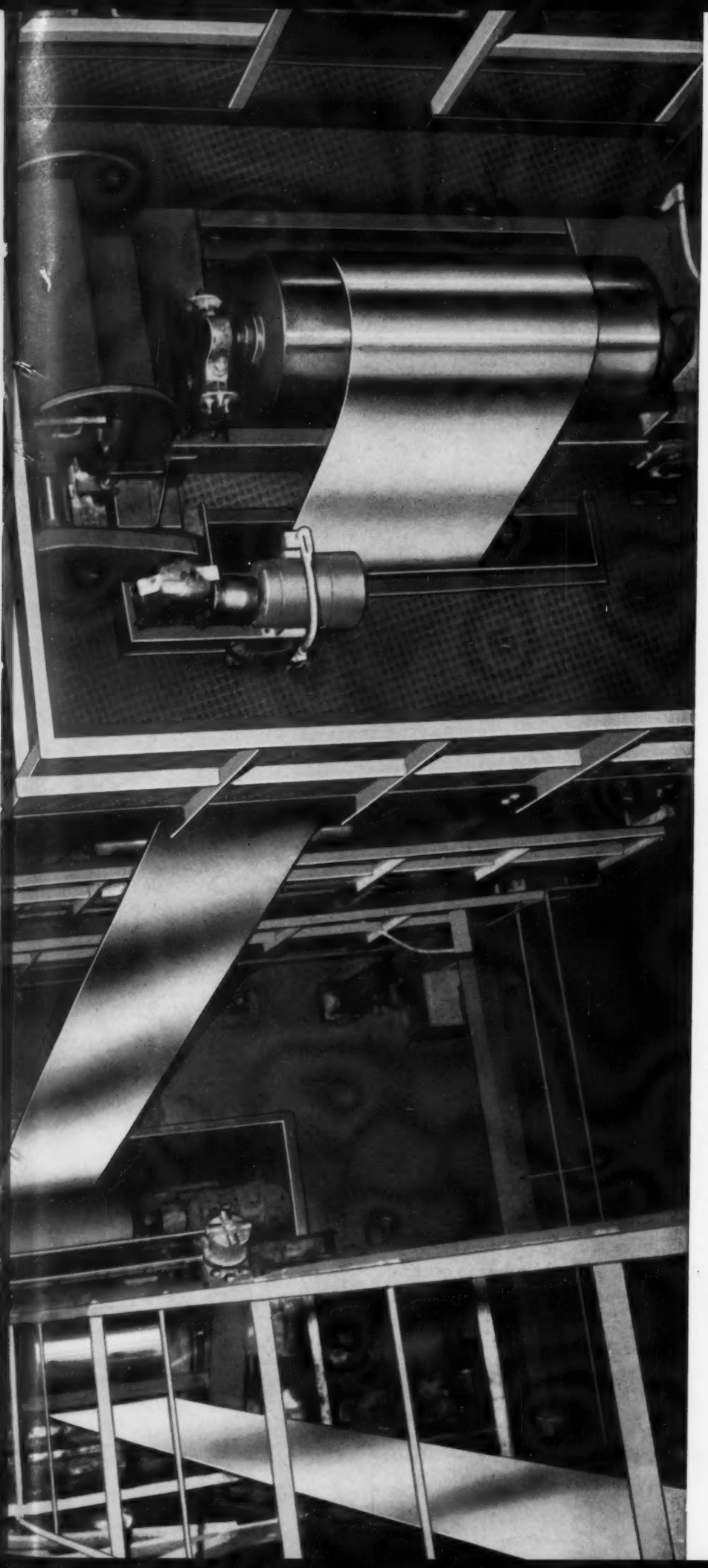

LIGHT GAUGES

at High Speeds

Need Rugged

Equipment

Each step toward paper-thin tin plate accentuates the operating problem. Tracking becomes more acute as speeds increase. Coils increase in diameter and weight. Tension becomes more critical.

The equipment must be heavy and rugged. High speeds with lower tensions in annealing, tinning and recoiling can only be accomplished with rugged equipment. Reels, both pay-off and tension, must be heavier to accommodate the bigger coils. New electrical controls are only practical when applied to sturdy mechanical equipment. Only rugged machinery, for which Aetna-Standard is noted, can stand up to 21-turn operation at high speeds with a minimum of strip breakage, down time and maintenance.

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AETNA-STANDARD DIVISION
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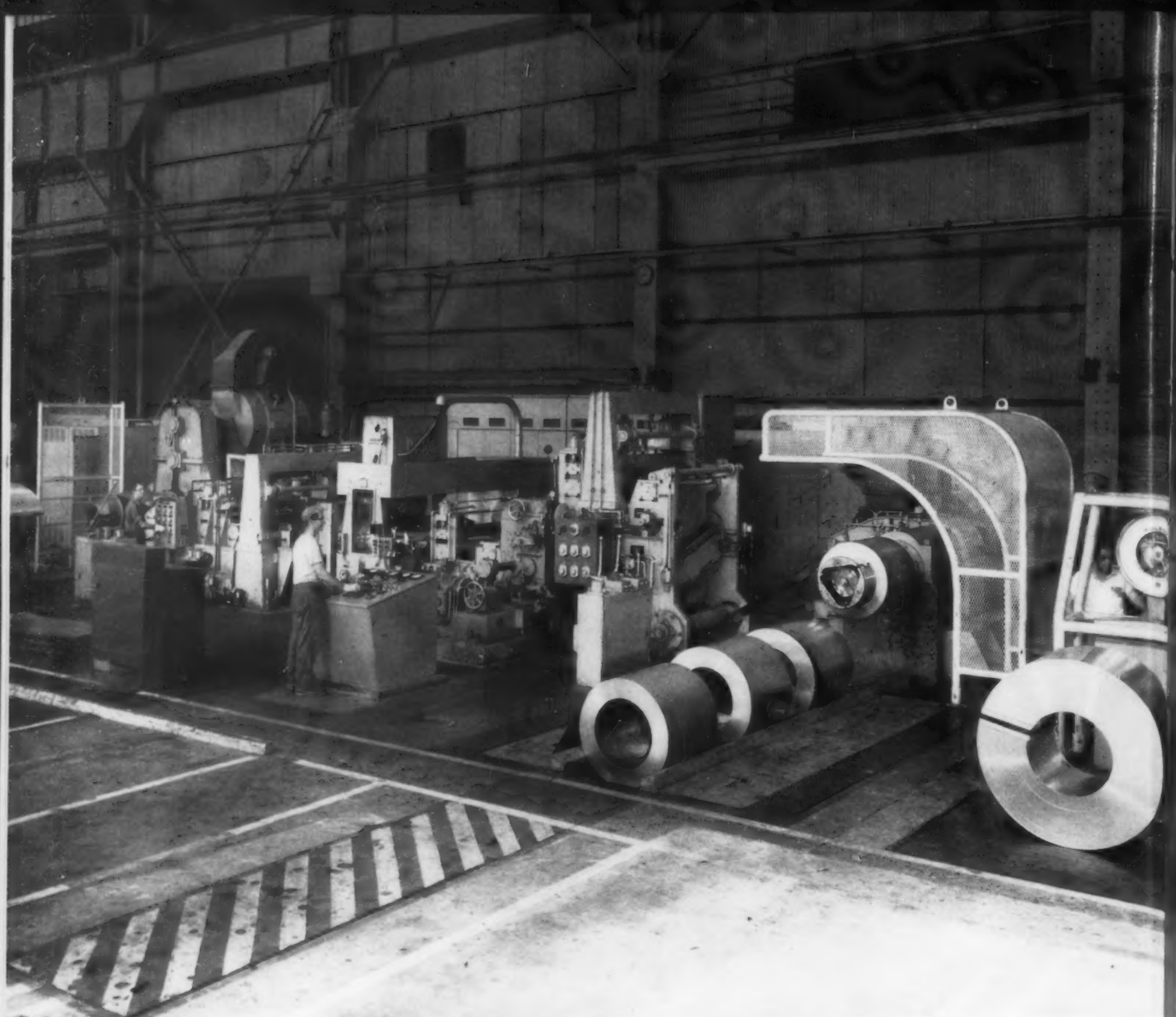
57 Years' Experience in Engineering Equipment for Processing ALL Gauges of Sheet and Strip



Wean coil preparation lines operate at 4000 fpm or more...

With Wean coil preparation equipment, you add materially to the efficiency of your tinning line operations—an important consideration in view of the increasing demand for tin plate in coil form.

Side trimmed coils up to 90" O.D. are produced for the electrolytic tinning lines, or smaller coils (see photo) are made for direct shipment to the customer as oiled black plate or other tin plate products.

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This spitfire is a lady now... thanks to the NATIONAL brush man!

R. H. SMITH

Smut piling up on commutators caused constant arcing in the 1250KW generators of this large smelting plant. *The reason:* improper brush selection, says "National" Carbon Brush Man R. H. Smith.

After analyzing work loads, Ron recommended "National" brush grade SA45. *Result:* no further arcing and improved commutation. This results in far easier maintenance.

Ron Smith is one of many "National" Carbon Brush Men serving industrial brush users all over the U. S. A. Their technical experience – plus "National" long term brush research – make them your logical consultants on any brush problem.

Call your local "National" office or write to National Carbon Company, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y.

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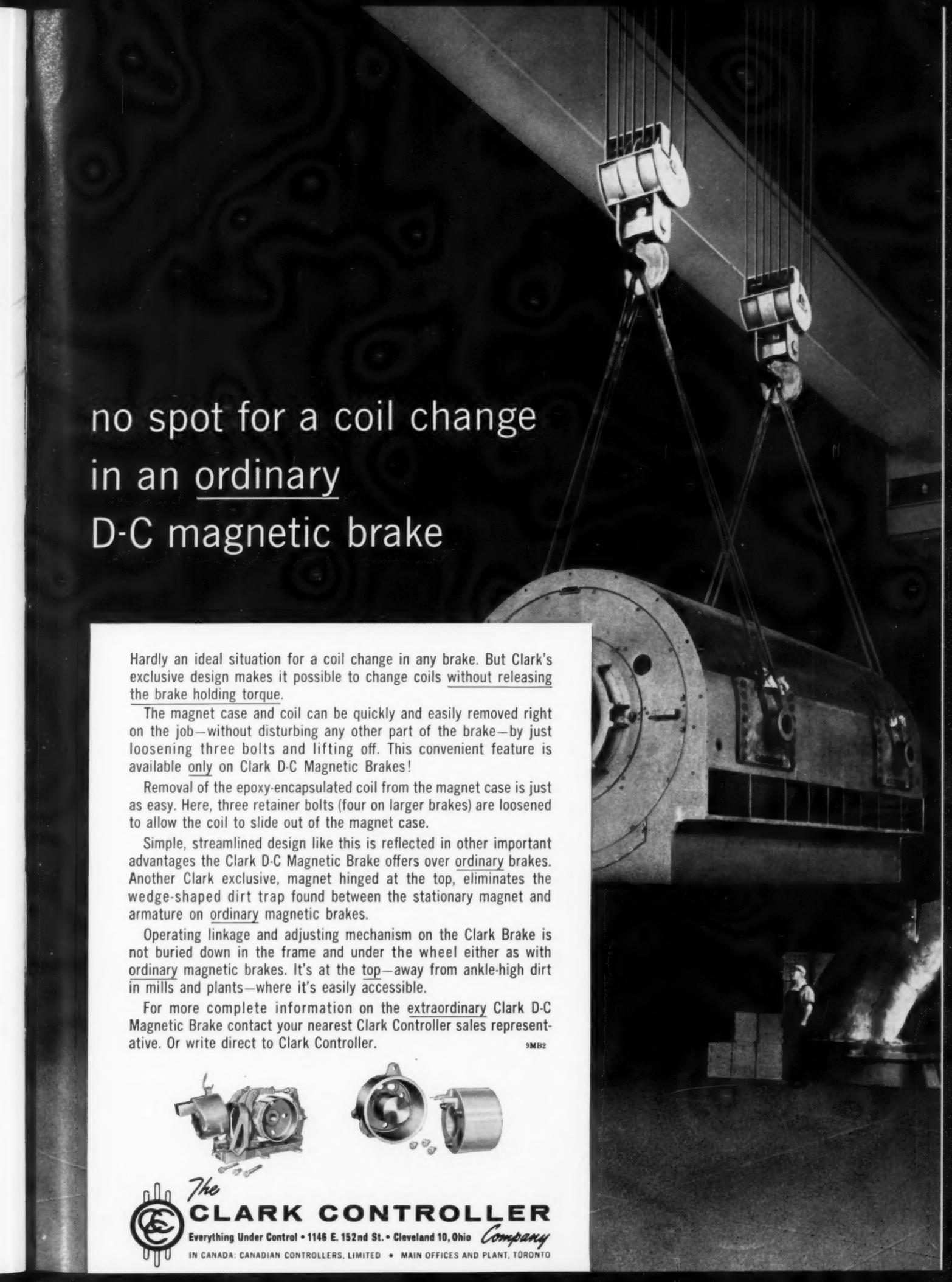

no spot for a coil change in an ordinary D-C magnetic brake

Hardly an ideal situation for a coil change in any brake. But Clark's exclusive design makes it possible to change coils without releasing the brake holding torque.

The magnet case and coil can be quickly and easily removed right on the job—without disturbing any other part of the brake—by just loosening three bolts and lifting off. This convenient feature is available only on Clark D-C Magnetic Brakes!

Removal of the epoxy-encapsulated coil from the magnet case is just as easy. Here, three retainer bolts (four on larger brakes) are loosened to allow the coil to slide out of the magnet case.

Simple, streamlined design like this is reflected in other important advantages the Clark D-C Magnetic Brake offers over ordinary brakes. Another Clark exclusive, magnet hinged at the top, eliminates the wedge-shaped dirt trap found between the stationary magnet and armature on ordinary magnetic brakes.

Operating linkage and adjusting mechanism on the Clark Brake is not buried down in the frame and under the wheel either as with ordinary magnetic brakes. It's at the top—away from ankle-high dirt in mills and plants—where it's easily accessible.

For more complete information on the extraordinary Clark D-C Magnetic Brake contact your nearest Clark Controller sales representative. Or write direct to Clark Controller. 9MB2

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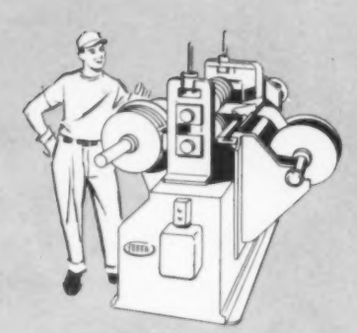
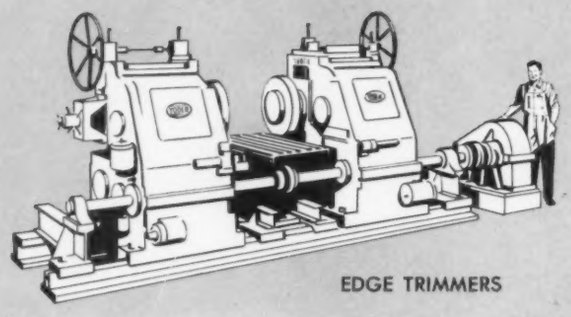
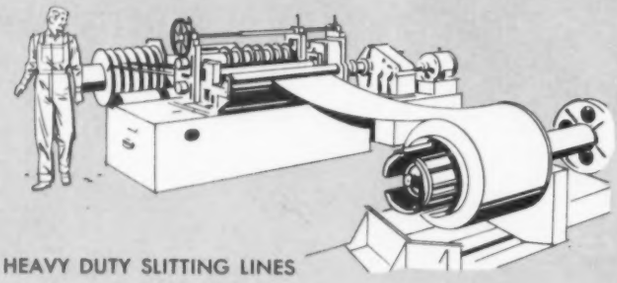


SELF-CONTAINED SLITTERS



EDGE TRIMMERS



HEAVY DUTY SLITTING LINES

YODER SLITTERS

basic equipment for cost-conscious users of strip!

To help meet the demands of tight production schedules, YODER Slitters reduce mill-width stock quickly and economically to desired widths. If your needs are as low as 100 tons per month, time and manpower savings alone will offset the cost of your YODER Slitter in a matter of months, while reducing basic inventories. Compactly designed, standard YODER Slitters are built to handle standard coil widths . . . completely engineered lines for special requirements.

YODER accessories, such as coil cars, swivel unloaders, scrap choppers, scrap disposers, plate levelers and coil boxes, make stock handling fast and easy.

YODER also makes a complete line of Cold Roll-Forming equipment and Pipe and Tube Mills. To profit from YODER'S years of engineering and service experience, contact your local YODER representative or send for the fully illustrated descriptive, YODER Slitter Manual; it's yours for the asking. Write to

THE YODER COMPANY
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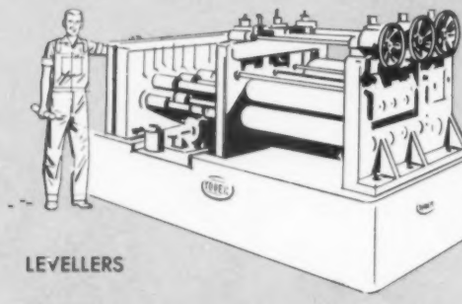

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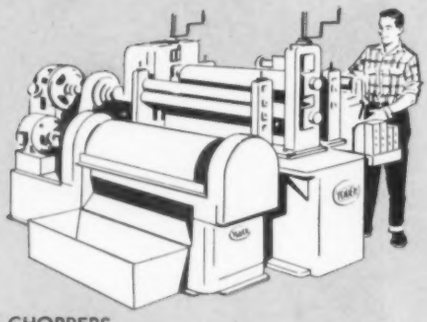
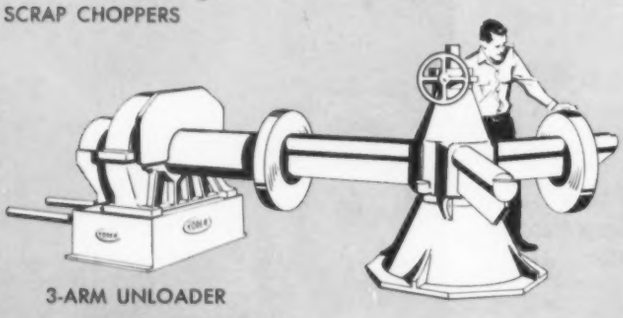


SCRAP CHOPPERS



3-ARM UNLOADER

COIL CARS

ENGINEERING **YODER** MANUFACTURING

ROTARY SLITTING LINES

PIPE AND TUBE MILLS (ferrous or non-ferrous)
COLD ROLL FORMING MACHINES

NOW

five big steelmakers...

have ordered pilot plants of the revolutionary Lee Wilson Opened Coil Annealing System

for a wide range of products, including tin plate, silicon and carbon steel coils, after tests at the Lee Wilson Research Center. The success of the Opened Coil Annealing System is based on economics and results. It costs less to install and operate than any comparable continuous equipment. It is a high production unit that permits exacting control of every inch of every coil, assuring the finest possible annealed product.

For your inspection, we have a 2-section mock-up of the 8-zone rotary furnace and an operating pilot unit of the batch type at our Research Center. We welcome test coils. We're sure that once you see it in operation and compare results you, too, will be convinced that the Opened Coil method is the answer to faster, better, more economical annealing.

Lee Wilson
ENGINEERING COMPANY, INC.
HIGH PRODUCTION ANNEALING SYSTEMS
MAKE THE BEST METALS BETTER
ORIGINATORS AND LEADING PRODUCERS OF OPENED COIL AND SINGLE STACK FURNACES

Now SKF has improved the spherical roller bearing it invented!

This new spherical roller bearing offers even higher capacity than SKF's original, self-aligning bearing – and meets the needs of today's faster, more productive machinery. In some cases, the increase in capacity is as much as 54% – corresponding to more than 4 times longer service life!

Here's how these improvements have been obtained:

1. Eliminating undercuts and integral flanges – helps provide space for larger rollers and longer effective contact between rollers and races.

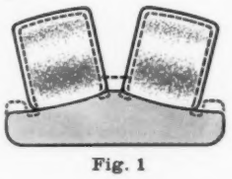


Fig. 1

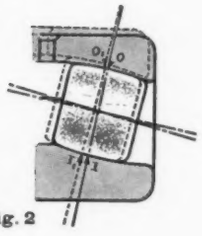


Fig. 2

2. Using symmetrical rollers, unrestricted by flanges – ensures uniform load distribution over the roller length at all times, even under heavy thrust load.

3. Using an axially floating guide ring – provides effective roller guiding, and minimizes friction at roller ends.

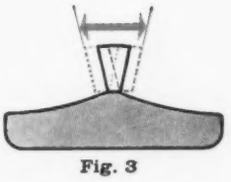


Fig. 3

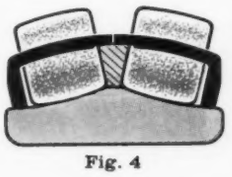


Fig. 4

4. Using a strong "window-type" cage for each row of rollers—helps ensure dependable operation over a full range of loads and speeds.

5. Placing a lubricant duct in the center of the outer ring—helps channel lubricants directly to the rollers and push contaminants away.

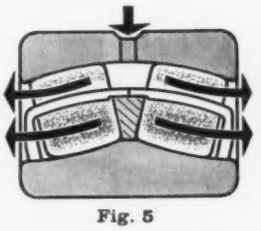


Fig. 5

For full details on this new high-capacity spherical roller bearing call the nearest SKF sales office or authorized SKF distributor listed in the yellow pages of the telephone book.

5931

Spherical, Cylindrical, Ball, and "Tyson" Tapered Roller Bearings

EVERY TYPE—EVERY USE

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Crops *and* Shorts

△ Steel Facts, published by the American Iron and Steel Institute, recently summed up some interesting statistics for the industry over the past 25 years. U. S. ingot capacity grew from 78,128,000 tons in 1934 to 147,633,670 tons in 1959. The number of producing companies increased from 77 to 82, with 20 companies now having 1,000,000 tons or more capacity. The number of blast furnaces increased from 243 to 266, with their annual capacity growing from 56,782,000 tons to 94,635,000 tons. The number of open hearth furnaces actually dropped from 995 to 920, while their capacity expanded from 71,472,000 tons to 126,528,000 tons. Electric furnaces only increased from 283 to 291, but annual capacity mushroomed from 1,500,000 tons to 13,495,000 tons. Bessemer converters shrunk from 44 to 31 in number, and from 7,213,000 tons to 3,577,000 tons in capacity, but 12 oxygen converters with 4,033,000 tons capacity have put in their appearance. Sheets, strip, pipe and tubes have increased their proportion of steel products shipments, now accounting for more than 48 per cent of the total. The automotive industry is still the largest customer but its portion of steel output dropped somewhat to the present 17.6 per cent.

During these 25 years, the industry spent about $14,800,000,000 for expansion and improvement.

△ According to reports, early sales of the "compact" cars are surprising dealers and manufacturers. People who have driven them are favorably impressed. The auto makers may be forced to the realization that not all cars should be "big." Everyone doesn't want a bulging monster.

△ Speaking of autos, we spend a lot of money to get cars that don't vibrate—then spend a lot more for chairs that will.

△ We'll hear more about labor-management negotiations in the railroad industry. The five operating unions are asking 12 to 14 per cent wage increase with a cost-of-living escalator clause. The 16 nonoperating unions want 25 cents an hour, plus company-paid life insurance, etc. The railroads are countering with a 15-cent-an-hour pay reduction—the amount by which rail employees' wages have exceeded those for general industry.

Also to be negotiated are work rules, including requirements for useless crewmen, rigid jurisdictional rules and the antiquated mileage-day pay system. These are estimated to cost the railroads more than $500,000,000 per year for work not performed or not needed. This waste has cut into the industry's competitive position to such an extent that 500,000 railroad jobs have disappeared over the past ten years.

This should give the steelworkers cause to reflect.

△ A traveler tells us of a sign in a restaurant in Juneau, Alaska: "Clam chowder, large bowl 50¢. Texas size 25¢.

And then there's the sign: "Cross street carefully. Avoid that *run-down feeling*."

△ Charles M. White, chairman of Republic Steel Corp., looks for a record steel production in 1960. He feels a reasonable estimate for ingot production would be a new record between 120,000,000 and 130,000,000 tons.

Mr. White also warned that we must learn to cope with the low-cost steel production of the rest of the world. The industry "is now faced with serious inroads of foreign steel in our domestic market and it is a new experience for us." He emphasized that the industry can successfully meet the foreign challenge "with advanced mechanization, the increasing capacity of our blast furnaces and open hearths, the advent of new processes and new methods, the increasing emphasis on research, the steadily improving quality of our steels, and, we hope, the co-operation of our labor unions."

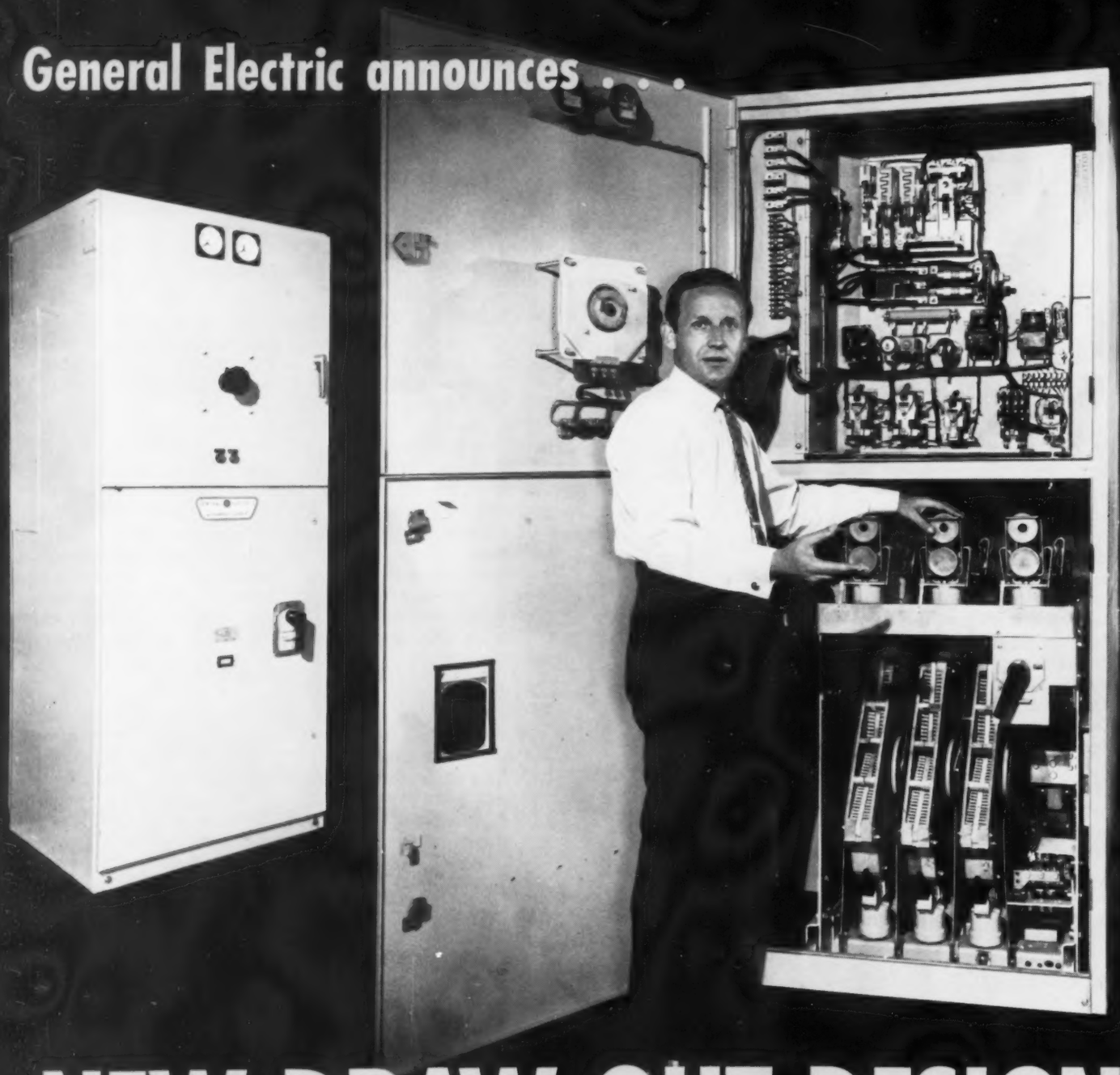
△ Innovations come slowly in steel plant equipment. Because the equipment is large and costly, companies are loath to venture too far into the untried. It is refreshing to read and think about possible improvements in our current equipment—and there's food for thought in the article on page 160 of this issue, describing a proposed new blast furnace with many new features. It will be interesting to watch for their adoption.

△ We've heard about a wonderful hobby: Lying in a hammock letting birds watch you.

△ A novel association, composed of retired research executives of some of the largest industrial companies in the United States, has been organized in New York. Under the name Team, Inc., (Technically Experienced Associates, Mobilized) these men offer their services in research and advisory work on problems in research management, scientific and technical education, public health, national defense, conservation of human and natural resources and scientific matters of national and international interest. Services are offered at cost plus a small overhead to cover office expenses.

Team, Inc., is sponsored by the Dorr Foundation, a nonprofit organization founded by Dr. J. V. N. Dorr of the Dorr-Oliver interests. President and chairman of the board is Herbert W. Graham, former vice president of research for Jones & Laughlin Steel Corp. The organization, with offices at 99 Park Ave., New York (16), will welcome as additional members retired research executives from broad fields of professional and scientific activity. The object of the group is to make the members' wide research experience available for the benefit of mankind without competing with commercial consultants. Two major studies are underway, one in the field of government and one in education.

General Electric announces . . .



NEW DRAW-OUT DESIGN

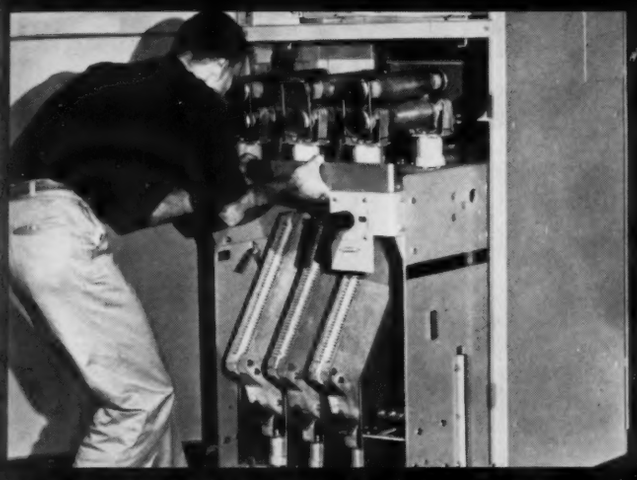
From General Electric comes the all-new draw-out Limitamp control—today's most advanced medium-voltage motor starter. Designed for the control of a-c motors rated 2300 through 4600 volts and up to 3000 hp, this new air-break starter has broad application throughout industry.

Since its introduction in 1941, Limitamp control has established a reputation for being first with the design features that add up to major user benefits. And, today's all-new Limitamp control follows this pattern with a host of design innovations that make for:

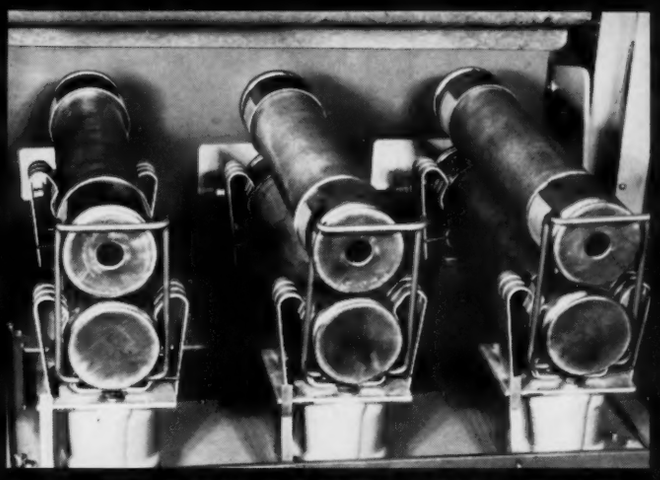
Faster installation: When you're ready to roll in the contactor—it can be done easily by one man. And, there are no connections to make—they are made automatically as the contactor rolls into place. There's plenty of space inside the panel for pulling the motor and power cables . . . and making the connections. And, with the new design, floor sills have been eliminated. This means no more grouting, no expensive cement work, simplified lineup with other panels.

Simpler, safer operation: One handle now controls the complete operation of connecting and disconnecting the starter from the bus and mechanically locking the high-voltage compartment door. A unique interlocking system protects the unit from misuse.

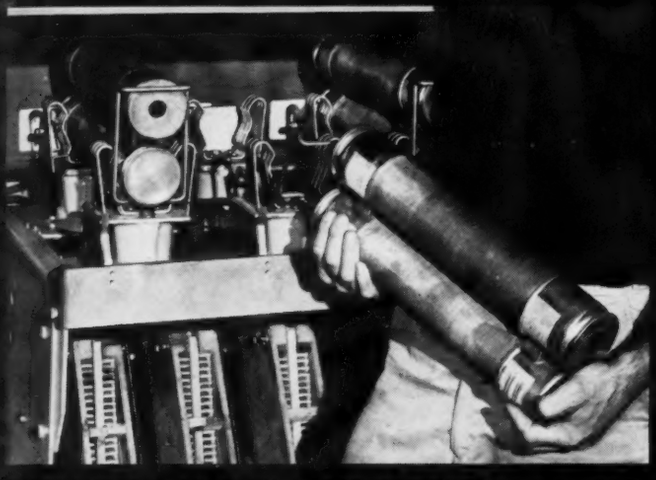
Superior protection: General Electric's new Limitamp



INSTALLS IN HALF THE TIME—Draw-out air break contactor, roomy isolated cable compartments, and increased working space help simplify installation.



LIMITAMP CONTROL IS ISOLATED AUTOMATICALLY—A unique shutter box isolates the starter from high-voltage power when the operating handle is turned to the off position.



INTERRUPTS FAULT IN FIRST ½ CYCLE—Fast-acting, current-limiting fuses interrupt circuit before short circuits cause damage to valuable motors.

NORMAL MAINTENANCE WITH CONTACTOR IN PLACE—All components, including the high-voltage contactor, can be maintained right in the control unit, with complete safety.

LIMITAMP* CONTROL

control utilizes fast-acting current-limiting fuses, ambient-compensated overload relays, and a high-voltage contactor to provide the most "positive" protection for your motors. Proved EJ-2 fuses interrupt a fault in the first ½ cycle, thus reducing damage to valuable motors. The performance of the completely coordinated design has been exhaustively tested in General Electric's high-voltage laboratory to provide the most reliable equipment for your application.

Easier maintenance: Even with these advanced design features, new Limitamp controls are simpler than ever to maintain. All components are accessible from the front for inspection and maintenance—without removing them from the enclosure. A special test circuit is built into each unit—permitting check-out operation before the unit is put into service.

For full information on all-new Limitamp motor control, contact your G-E Apparatus Sales Engineer or Agent today. Or write Sect. 783-10, General Electric Co., Schenectady, N. Y., for Bulletin GEA-6893. Industry Control Dept., Roanoke, Virginia.

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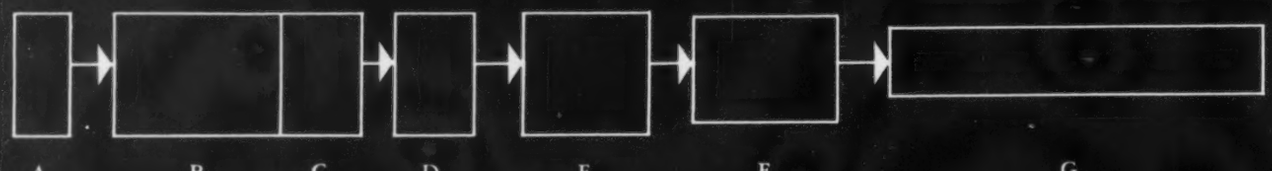
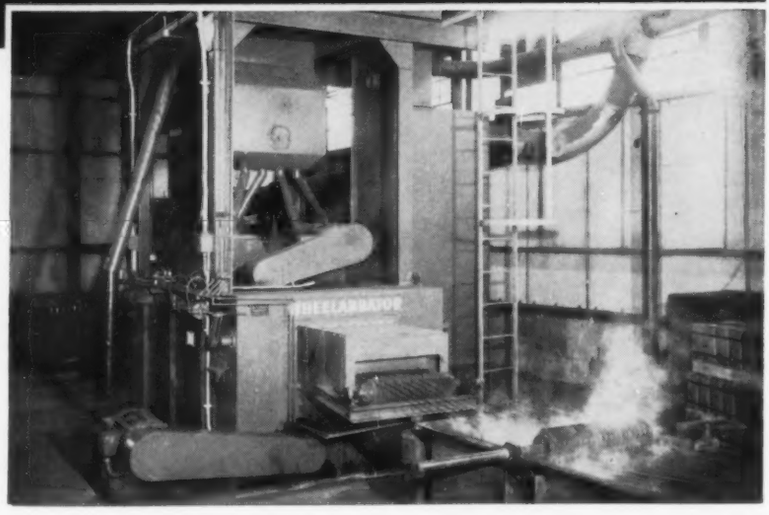
FROM HOT ROLLED ROD THROUGH PATENTING, CLEANING AND COATING IN ONE CONTINUOUS OPERATION



THE LESCHEN WIRE ROPE DIV. AUTOMATED STRAIGHT-LINE PRODUCTION METHOD

A. Twelve-strand Payoff Reels.
B. Rod Annealing Furnace.
C. Lead Quench (Patenting).
D. Water Quench.
E. Wheelabrator Abrasive Blast Descaling Cabinet.
F. Borax Coating and Drying.
G. Horizontal Takeup Recoilers.



Leading producers of wire products are now using Wheelabrator® straight-line abrasive blast descaling as the shortest distance between steel rod and wire profits. At H. K. Porter Company, Inc., Leschen Wire Rope Division, St Louis, for example, this process is resulting in exceptional production efficiency and economy.

The automated processing line starts with hot rolled rod, and in one continuous operation produces cleaned and coated rod for subsequent drawing. Wheelabrator mechanical blast descaling is an essential step in this process. It cleans twelve strands at a time in line with patenting, coating and drying and delivers cleaned and coated rod for multiple hole drawing. There is no interruption and no intermediate handling required. Furthermore, the line operates continuously five days a week, 24 hours a day without downtime.

All scale or rust is completely removed down to virgin metal, at speeds required for patenting. The fine matte finish obtained holds a more uniform coating and provides excellent drawing characteristics. This blast descaling process offers freedom from the problems associated with acid pickling. And, through automated production, important additional savings in time and labor costs are achieved by reducing "in process" inventories.

It will pay you to consider this new process for cleaning any type of ferrous or non-ferrous hot rolled rod and bar stock for cold drawn products.

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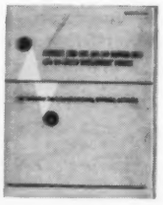
HOW TO AUTOMATE YOUR WIRE DRAWING LINE

This new booklet explains how Wheelabrator blast descaling can enable automation of your wire production. Write for Bulletin 148-D.



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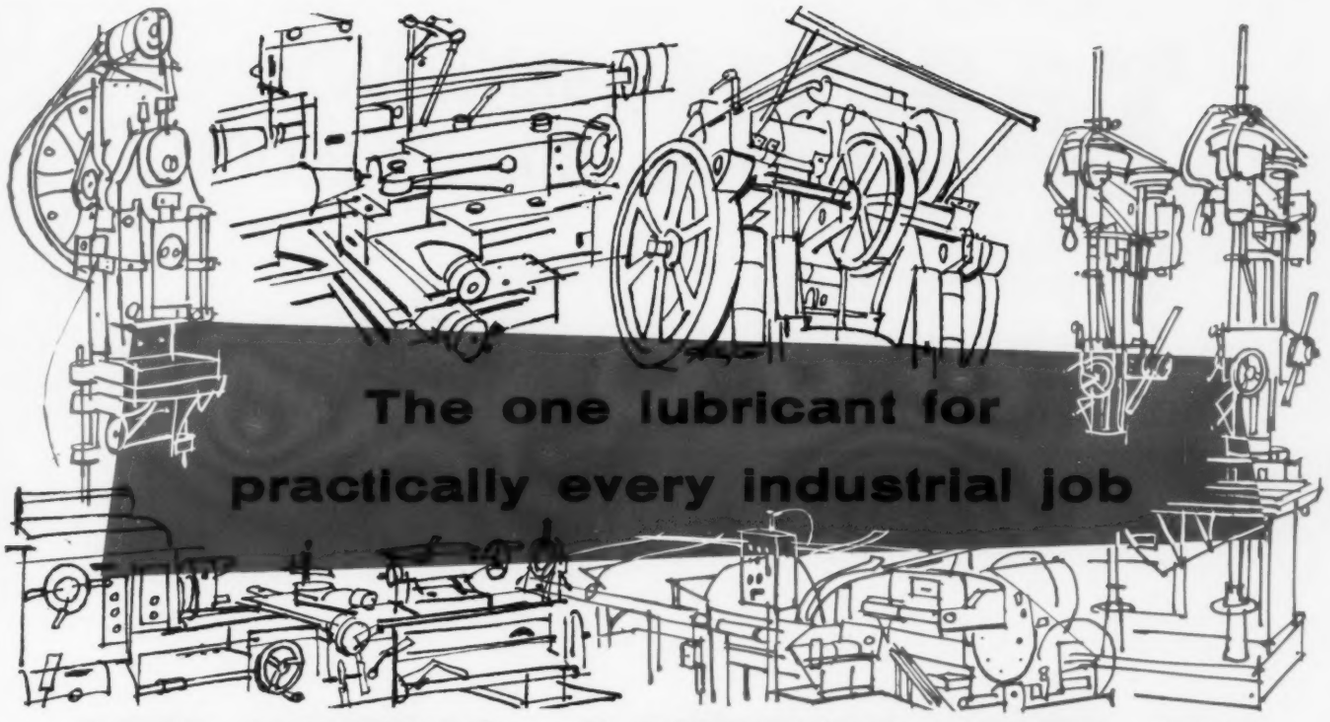

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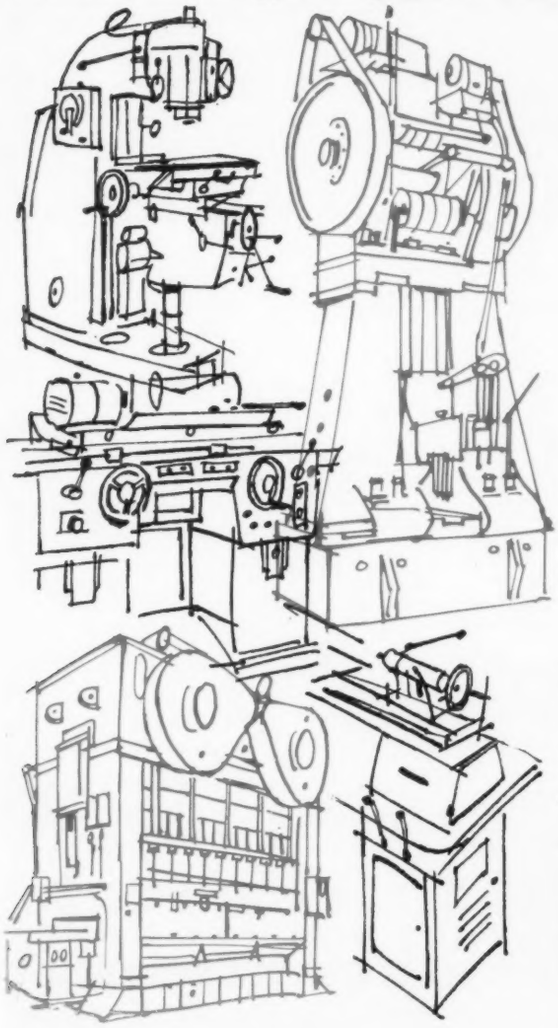

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- **Wider application**—almost universal application to grease-lubricated equipment in plants of all sizes
- **Excellent performance** at very high to extremely low operating temperatures
- **Reduced losses** from lubricating error
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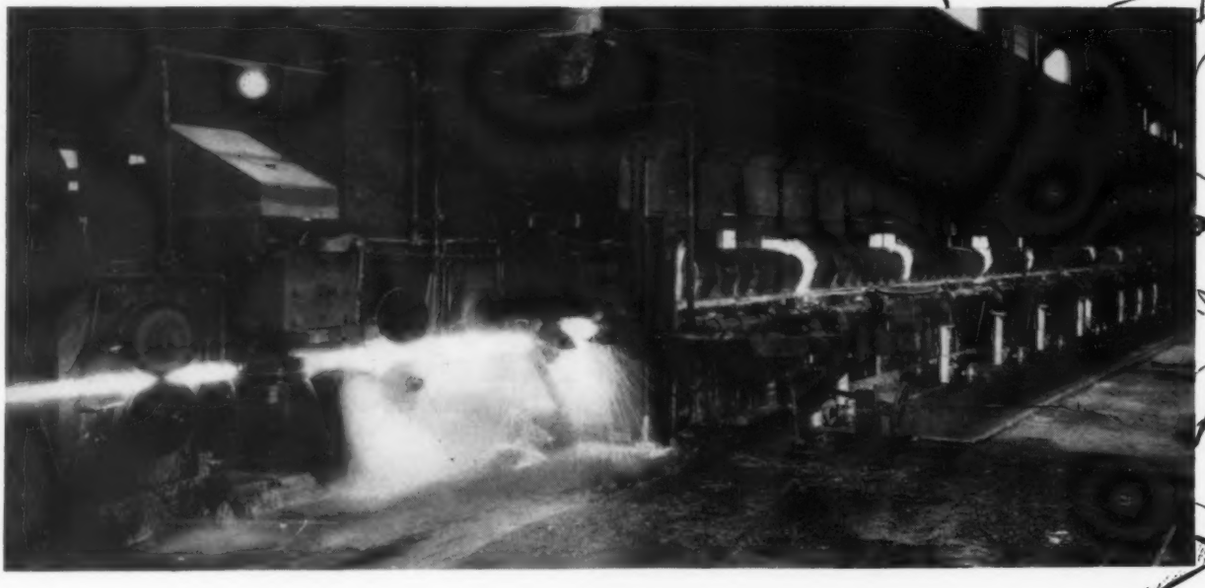

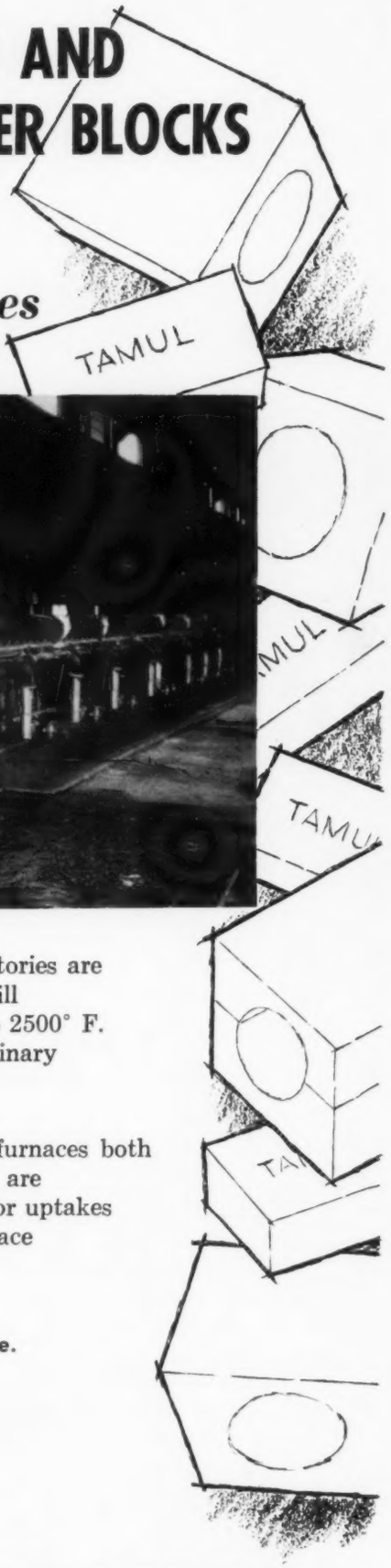

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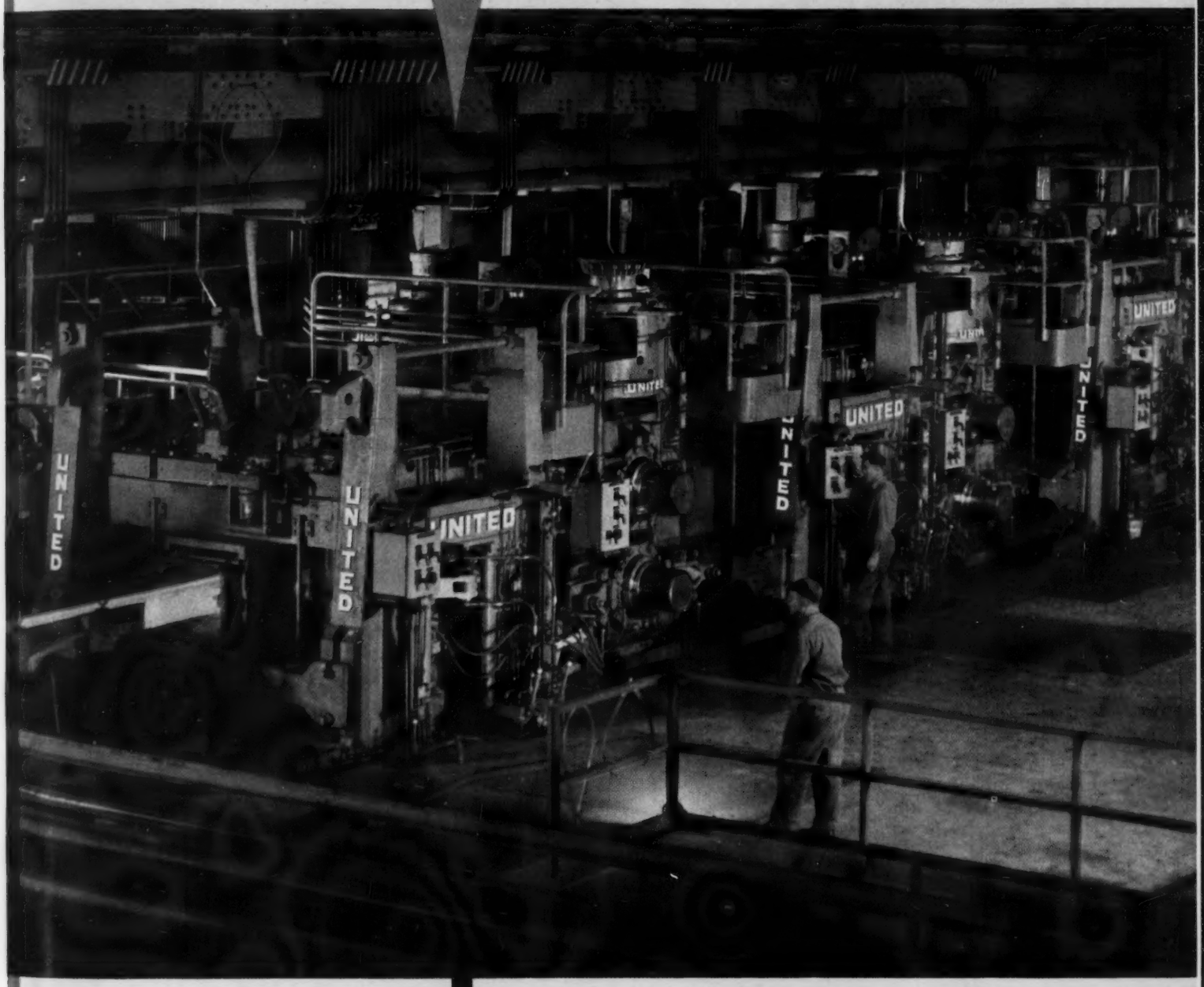

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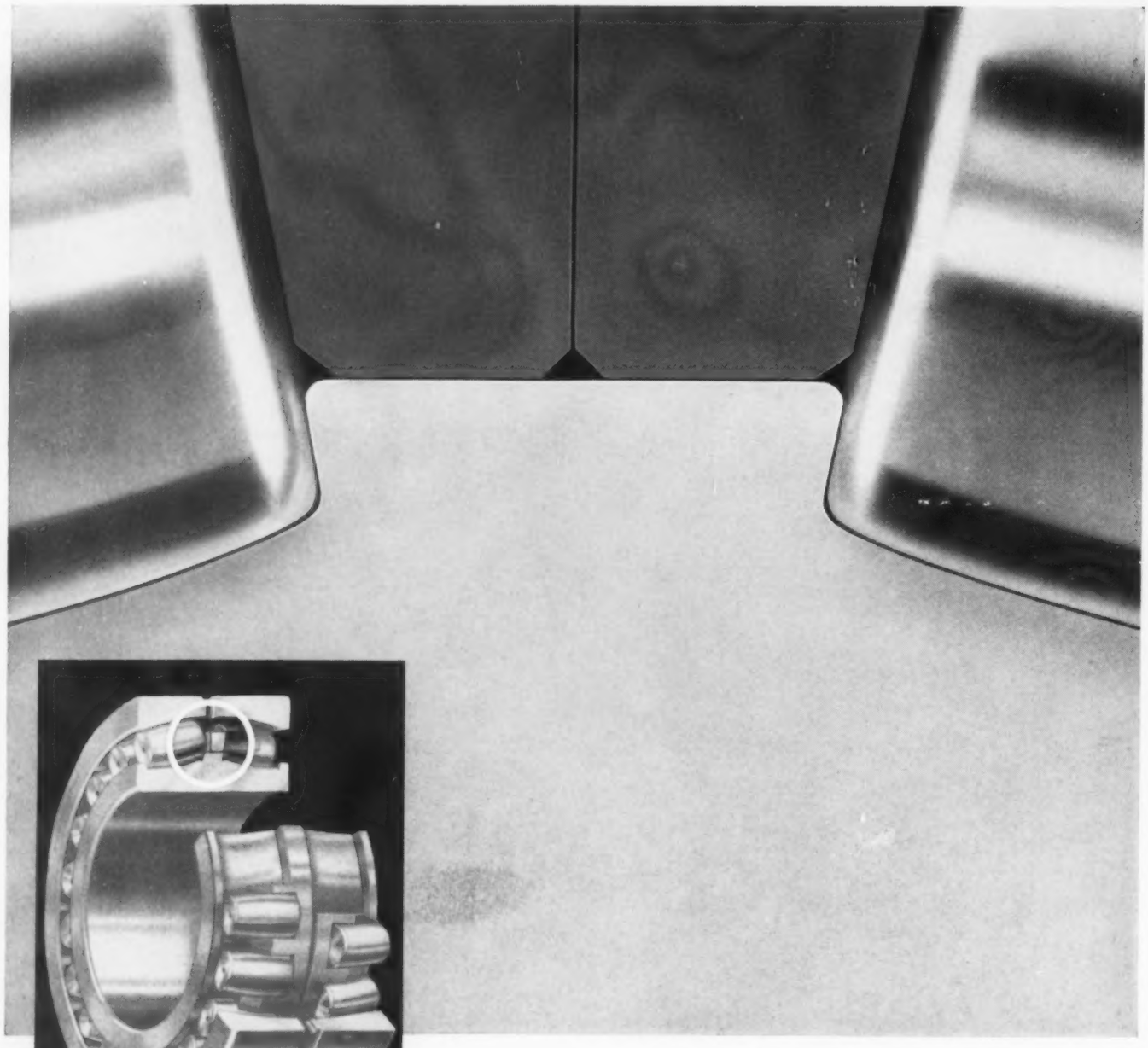

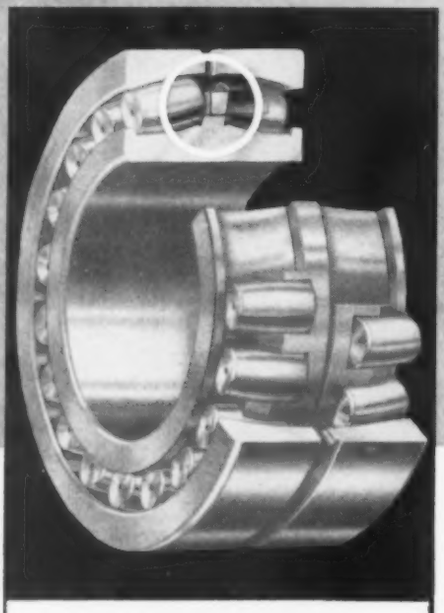

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The integral center guide flange of the *Torrington* Spherical Roller Bearing provides *positive* roller guidance—the one best way to insure operating stability under radial and thrust loads.

Center guide flange surfaces and roller ends are ground to a common spherical radius. The asymmetrical roller seeks this flange under load, bearing lightly but constantly against it. Roller wobble and skewing are eliminated, and stress concentrations leading to early failure are avoided. Bearing operation is cooler, quieter and smoother.

The integral guide flange is adapted from the same principle used in the design of Torrington Tapered Roller Bearings. It is an engineering refinement, based on experience in all types of applications, that insures outstanding performance in your equipment. **The Torrington Company, South Bend 21, Ind.—and Torrington, Conn.**

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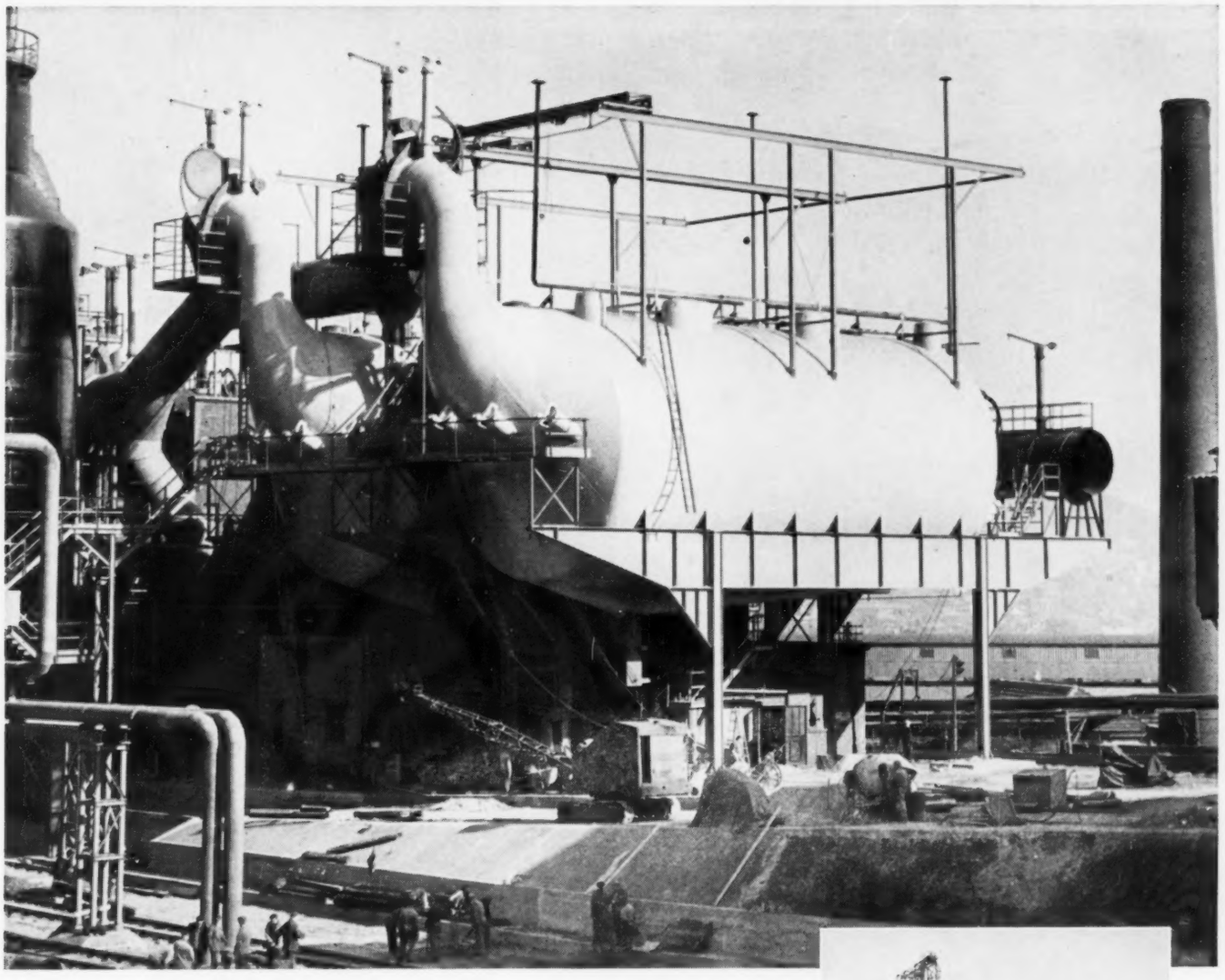

BELOW 0.002 grains/cu ft

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Gas quantity: 140,000 cfm. Design pressure: 21 psi.

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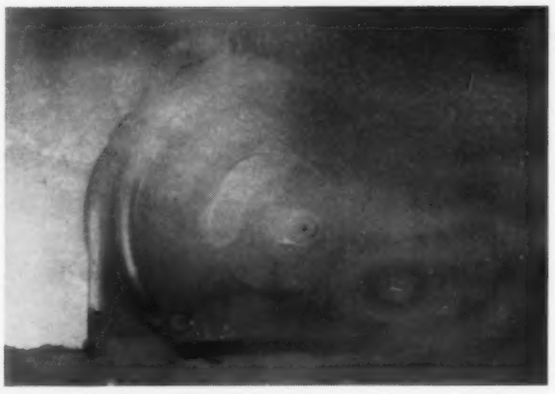

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for weeks at 75° C below zero!

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ALLIS-CHALMERS A-C A-1151

patent reviews

By MELVIN NORD, Patent Attorney, Detroit, Mich.

Copies of patents may be obtained from the Commissioner of Patents, Washington 25, D. C. at 25 cents . . . . patents reviewed cover period May 26, 1959 through June 16, 1959.

DIRECT REDUCTION OF IRON OXIDE ORES

△ U. S. 2,889,219, issued June 2, 1959, to James W. Halley and assigned to Inland Steel Co., describes a process for the direct reduction of iron oxide ores by means of carbon monoxide gas.

As shown in Figure 1, the reduction zone comprises a refractory lined column 10 having an upper portion 11 of relatively enlarged diameter and a lower portion 12 of reduced diameter. Subdivided or granular iron oxide ore is fed into the enlarged upper section 11 through a screw conveyor mechanism 13 from a supply source or ore preheating source (not shown), and CO rich reducing gases are introduced through a line 14 to the bottom of the reduction column 10. The ore which may be used in the process comprises any of the well known iron oxide ores including hematite, magnetite and others which may contain at least about 5 per cent and as much as 45 per cent by weight gangue materials, particularly silica and alumina.

It is preferred to utilize a countercurrent nonfluidized moving bed operation in which the column of ore solids moves downwardly in countercurrent contact with the upwardly flowing reducing gases. In the apparatus shown schematically in Figure 1 the downwardly flowing bed of ore solids is supported at its lower end by a cone-shaped partition 16 which communicates with one end of another screw

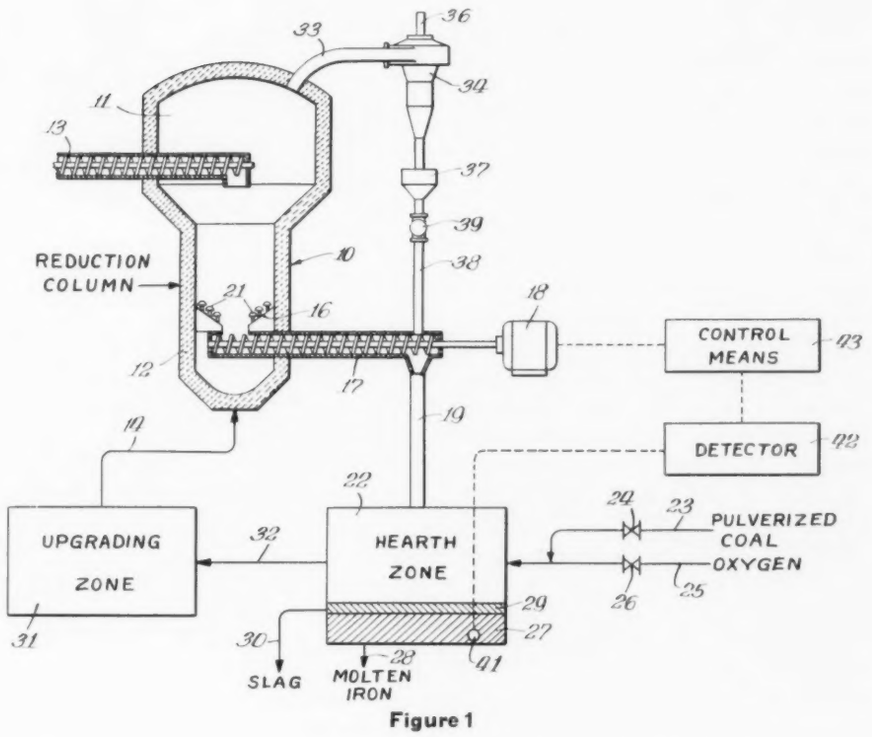


Figure 1

conveyor 17 operated by a motor 18 for discharging the reduced ore solids from the reduction column 10 to a hearth feed line 19. The partition 16 is provided with suitable protected gas passages, such as the bubble cap element 21, whereby the reducing gas introduced through the line 14 at the bottom of the column 10 may pass upwardly through the partition 16 and then in countercurrent relation with the downwardly moving bed of ore particles.

In the reduction column 10 the well known reduction reactions of iron oxide with CO (and H_2) take place with the heat of reaction being supplied by the sensible heat of the reducing gases at a temperature of from about 900 to about 1800 F. The resultant ore solids, comprising reduced iron, gangue and a certain amount of unreduced iron oxide, pass through the hearth feed line 19 to a hearth zone illustrated at 22. The hearth zone 22 comprises a combined melting and gas generator zone in which a fuel is burned with a high oxygen content gas. Preferably, the fuel comprises a solid carbonaceous material such as anthracite,

bituminous or subbituminous coal. In order to supply the thermal requirements of the melting operation, the relative quantities of coal and oxygen and the other combustion conditions in the hearth zone 22 are regulated so that the CO_2:CO ratio in the exit combustion gases is at least one with the result that the gases in the hearth zone are oxidizing to iron. In this way, a temperature of from 2900 to 3500 F is obtained in the hearth zone so that the heat of combustion is sufficient to insure melting of the iron in the reduced ore particles, thereby separating the same from the gangue. Molten iron, indicated at 27, is removed from the hearth zone 22 through a line 28, and a fluid slag 29 formed from the ash in the coal and the gangue in the ore is removed through a line 30.

Since the combustion gases produced in the hearth zone 22 contain an excess of CO_2, they must be subjected to an upgrading or enrichment treatment before they can be used for ore reduction purposes. Preferably, the upgrading or enrichment of the combustion gases is effected by reducing the CO_2 content by reaction with carbon.

The depleted or "spent" reducing gases pass from the top of the reduction column 10 through a line 33 to a cyclone separator 34 where entrained fine ore particles are removed. The off gases are discharged through a line 36 and the ore fines are collected in a hopper or storage vessel 37 which is connected by a line 38 and a valve 39 to the discharge end of the screw conveyor 17 whereby the ore fines may be charged through the hearth feed line 19 to the hearth zone 22.

COMPOSITION FOR HOT TOP LINING

△ U. S. 2,890,504, issued June 16, 1959, to Robert E. Daley and Benjamin F. Anthony, assigned to Oglebay Norton Co., relates to composite hot tops used in casting steel ingots, as shown in Figures 2 and 3.

In the ordinary hot top, upon removal of the hot top from the sinkhead of the ingot, the slanting walls of the sinkhead do not provide a condition which facilitates the gripping by the jaws of the stripper crane or soaking pit crane tongs,

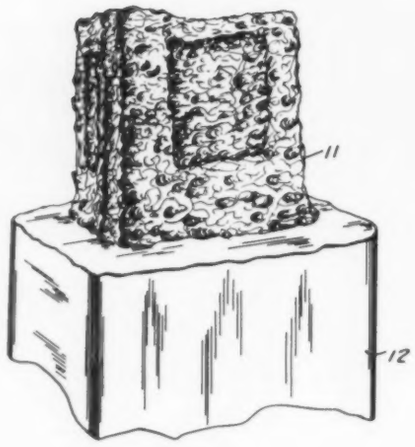


Figure 2

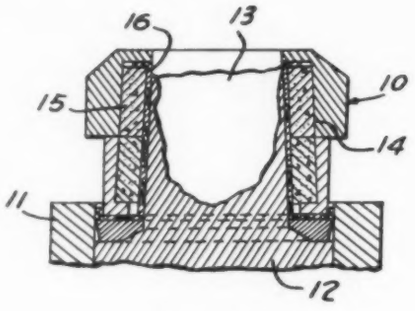


Figure 3

when they engage the sinkhead to strip the ingot from the ingot mold. The difficulties involved have at times caused accidents with incident injury to personnel, as well as damage to the soaking pits and adjacent tracks or indeed to the crane itself.

The present invention provides a way of indenting in an irregular manner and roughening the sinkhead surface, to obtain a secure gripping by the tongs of the cranes when the ingot is stripped from a mold or otherwise handled. This is accomplished by incorporating into the compound, used to form the veneer on the inner surfaces of the hot top, a material which upon contact with the heat of the sinkhead metal, when an ingot is poured, produces the effect of roughing and indenting in an irregular manner the surface of the sinkhead.

When the interior lining or veneer for the hot top is composed of suitable proportions of a granular refractory material such as sand and a carbonaceous material such as coke breeze, anthracite silt, sawdust or bone black, together with a suitable plasticizer and binder, and when the hot top is stripped or removed from the sinkhead, it is found that the sinkhead surface has, during the solidification of the ingot and sinkhead, pulled away from the lining or veneer and there has been imparted to the surface of the sinkhead an irregular indented portion or portions and in general a roughened surface has been produced.

The foregoing results not only in producing a condition favorable to the effective bite of the crane tongs upon the sinkhead, and so minimizing any opportunity for slippage, but also it is found that the veneer has become more or less disintegrated and is easy to remove from the refractory linings of the hot top, all of which facilitates the conditioning of the refractory lining of the hot top to receive a new application of the veneer in preparing the hot top for a subsequent use in casting.

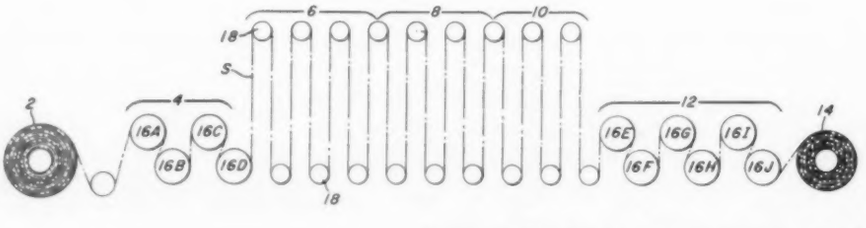
CONTINUOUS ANNEALING OF STEEL STRIP

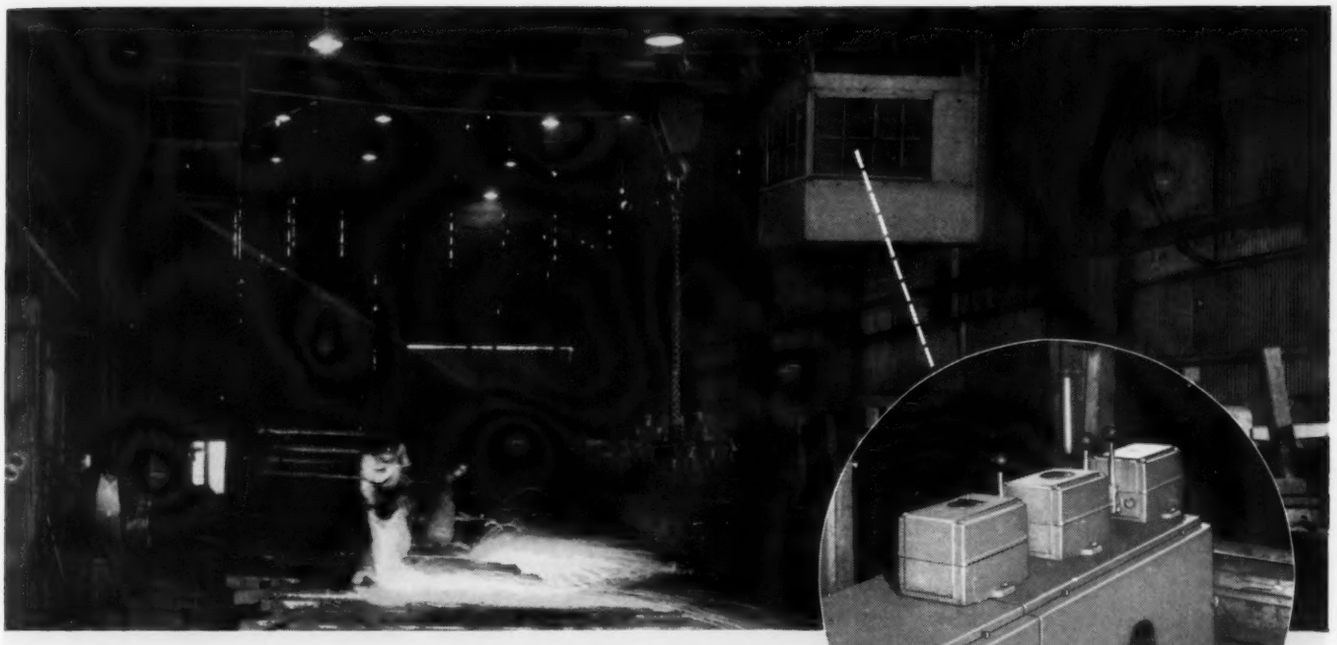
△ U. S. 2,890,037, issued June 9, 1959, to George H. Rendel, assigned to United States Steel Corp., describes a strip temperature control for cooling steel strip as it passes over a number of rolls, in a continuous annealing process.

In Figure 4, numeral 2 indicates an uncoiler from which strip to be annealed is uncoiled. After passing through various conventional equipment, the strip passes through a preheating zone 4 and then successively through a heating zone 6, holding zone 8, slow cooling zone 10 and a fast cooling zone 12 from which it passes to a coiler 14.

As shown in Figure 5, the rolls 16 are hollow and have a wall 20 surrounding a chamber 22 which

Figure 4





MODERNIZE DC Cranes with EC&M "PT" Magnetic Control

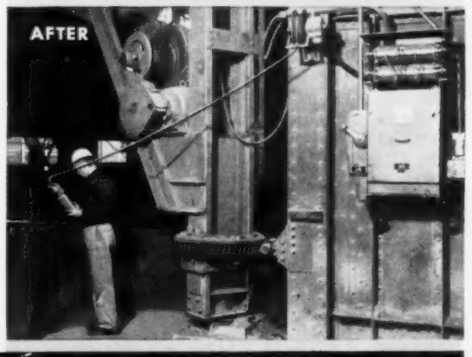
Three-motion crane serving scarfing area in mid-western steel plant uses "PT" control for bridge, trolley and hoist motions. EC&M Tab-Weld resistors are mounted on bridge foot-walk. Two "PT" controllers, replacing manual controllers, are mounted at front of cab. Third controller is at rear of cab, and all three master switches are up front within easy reach of operator. Since converting to "PT" control, there is more room in cab.

Is *manual* control penalizing crane operation in your plant? Are motors and machine subjected to abnormal conditions during acceleration and plugging? Is output affected by the slower reaction of operators as they tire under the strain of manual control on an all-day's run?

EC&M "PT" Magnetic Control erases these deficiencies. Timed acceleration and rectifier-plugging protection cuts motor abuse. Compact, easy-operating master switches provide a new "feel", enabling the operator to increase output.

The illustrations shown here are typical of the acceptance of EC&M "PT" control for DC Cranes. One plant has a modernization program under way involving dozens of cranes. Physically, "PT" control occupies about the same space as manual control. The cost is comparable, too.

Convert now to "PT" control. This *magnetic* control is far superior to manual control.



Jib crane, shown at top with old manual controller, is now operated by "PT" magnetic control (bottom). Pendant pushbutton provides remote control, gives operator better view of open hearth floor. "PT" control can be operated, without change, by either master switches or pendant pushbutton. "PT" control is front wired, front accessible, for mounting against walls or crane girders.

Write for complete details on "PT" crane control. Ask for Bulletin 6131.

2950

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CLEVELAND 28 • OHIO

WHEREVER ELECTRICITY IS DISTRIBUTED AND CONTROLLED

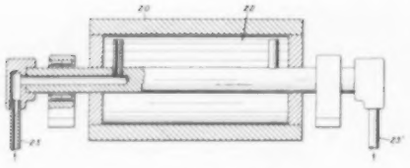


Figure 5

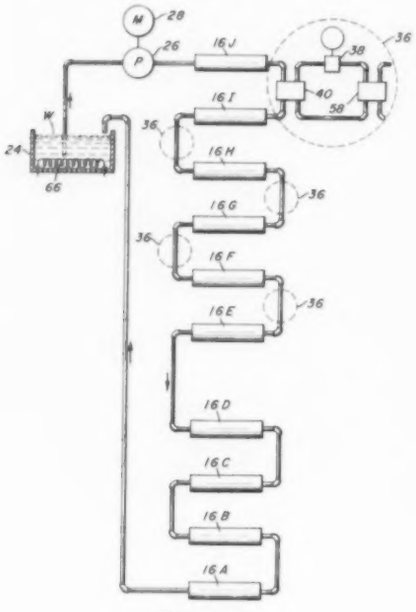


Figure 6

receives a heat exchange medium through a conduit 23 and exhausts it through conduit 23′. The heat exchange medium may be a nonflammable oil, liquid silicone or other suitable fluid which will withstand relatively high temperatures. As shown in Figure 6 the heat exchange medium W is delivered from a storage tank 24 by means of a pump 26 driven by a motor 28 to the roll 16J at the exit end of the series of rolls and then successively through rolls 16I, 16H, 16G, 16F and 16E and then through rolls 16D, 16C, 16B and 16A back to the storage tank 24. This arrangement causes the surface temperature of the rolls to increase from the roll 16J to roll 16E and to decrease from the roll 16D to the roll 16A.

For some installations it may be necessary to utilize a temperature control system 36 to regulate the temperature of the heat exchange medium W as it enters one or more of the conductor rolls. The operation of this control is described in detail in the patent.

GALVANIZING APPARATUS

△ U. S. 2,889,803, issued June 9, 1959, to William S. Pearson, describes improvements in galvanizing apparatus, having the object of reducing the fire hazard caused by the affinity of zinc dust for oxygen.

Several means are provided for reducing the fire hazard, including: (1) diversion into the spatter chamber of the low-oxygen exhaust gas of the zinc pot; and (2) introduction of an atomized spray of oxygen-absorbing high-flash oil into the spatter chamber, thereby reducing the available oxygen.

COATING CONTROL APPARATUS

△ U. S. 2,888,901, issued June 2, 1959, to Henry W. Nieman and George O. Maish, assigned to Bethlehem Steel Co., describes an apparatus for applying a liquid coat to a steel strip.

The apparatus includes a receptacle containing the coating bath, through which the strip passes, and a pair of spaced rolls at the exit of the bath partly submerged in the bath through the bite of which the strip emerges from the coating bath.

A device is also provided to prevent excessive coating material from passing through the rolls, along with the strip and building up on its edges. This device engages the edges of the strip and the rolls adjacent the edges of the strip.

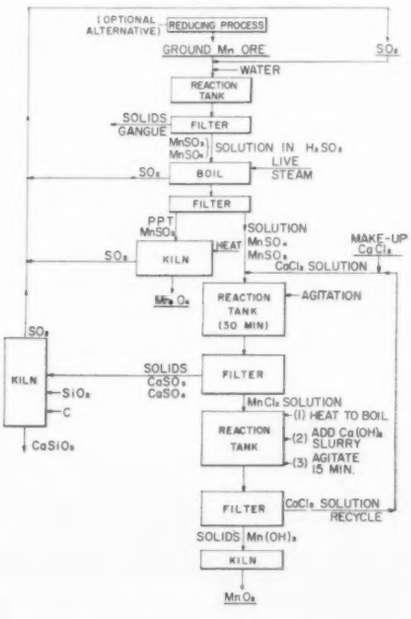
RECOVERY OF MANGANESE FROM ORES

△ U. S. 2,890,103, issued June 9, 1959, to Charles C. Dougherty, assigned to Republic Steel Corp., describes a process for the recovery of manganese from low grade ores containing relatively large amounts of iron, such as the ores found in Aroostoock County, Maine.

The process also permits the recovery and recycling of substantially all the sulphur dioxide used for leaching the ore.

The process is shown schematically in Figure 7.

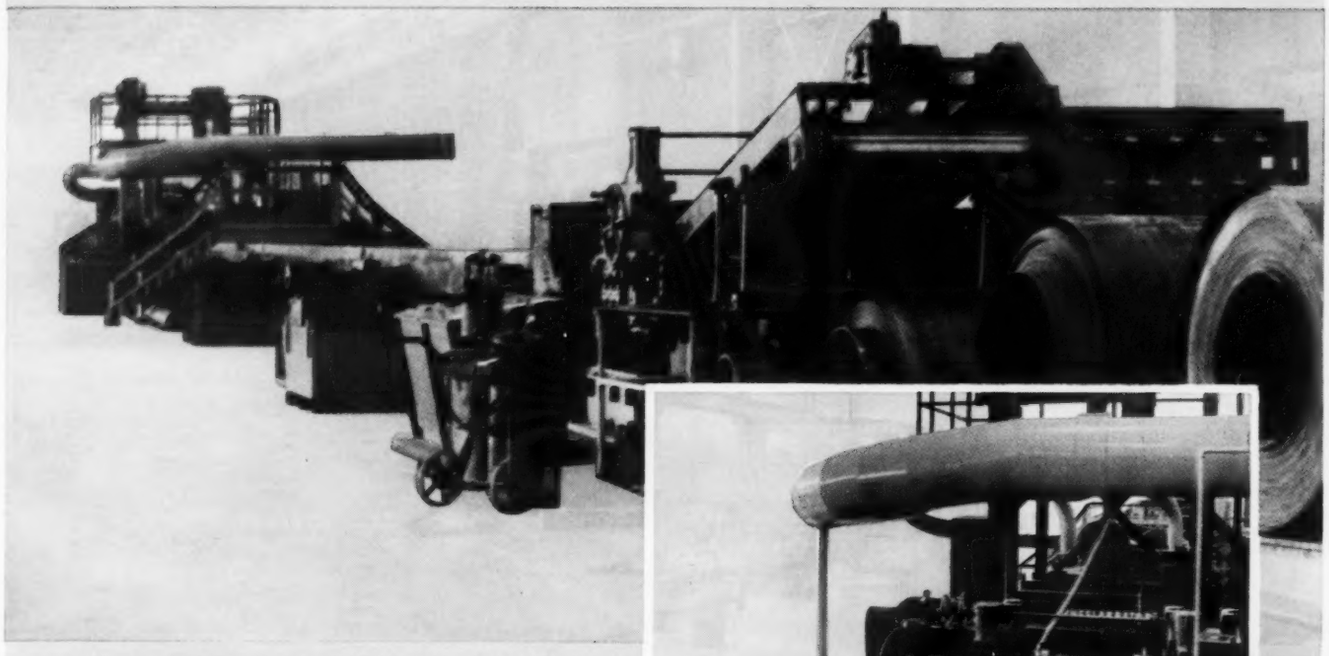
Figure 7



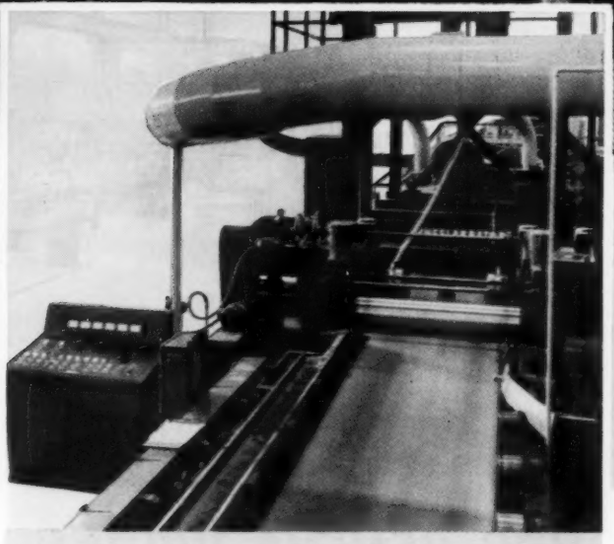
OTHER PATENTS OF INTEREST TO THE IRON AND STEEL ENGINEER

Patent No.	Date	Subject	Inventor or assignee
2,887,914	5/26/59	Mandrel-protecting device for cold-pilger rolling mills	Mannesmann-Meer A.G.
2,887,915	5/26/59	Gap mill control	The National Machinery Co.
2,887,962	5/26/59	Latching mechanism for ladle cars	United States Steel Corp.
2,888,255	5/26/59	Open-hearth furnace with inclined side walls	Societe Anonyme "Cockerill-Ougree"
2,888,341	5/26/59	Pelletizing iron ores	The Dow Chemical Co.
2,888,373	5/26/59	Differential age hardening of austenitic steels	Thompson-Ramo-Wooldridge, Inc.
2,888,374	5/26/59	Depth-hardening of long tubes	Mannesmann A.G.
2,889,222	6/2/59	Production of nodular iron	Union Carbide Corp.
2,889,223	6/2/59	Stainless steel alloy	Electric Steel Foundry Co.
2,889,597	6/9/59	Foundry ladle transfer car	Whiting Corp.
2,889,912	6/9/59	Apparatus for downtilting heavy articles	United States Steel Corp.
2,890,038	6/9/59	Sintering machine apparatus	Koppers Co., Inc.
2,890,046	6/9/59	Conveyor with tracking control	Armco Steel Corp.
2,890,113	6/9/59	Steel alloy of great tenacity	Interstahl Etablissement
2,890,140	6/9/59	Iron alloy having antiwarping characteristics	National Malleable & Steel Castings Co.
2,890,143	6/9/59	Annealing process for minimizing core loss in hot-rolled electric sheet segments	Jakob Bingel
2,890,608	6/16/59	Safety mechanism for a draw rolling mill	A. O. Smith Corp.
2,890,609	6/16/59	Entry sticker guide for rolling mills	E. W. Bliss Co.
2,890,653	6/16/59	Rotary printing press for continuous metal strip	Jerome R. Share
2,890,955	6/16/59	Austenitic stainless steel alloy	Standard Oil Co.
2,890,974	6/16/59	Passivation of stainless steel alloys	Fairchild Engine & Airplane Corp.

Stamco * heavy gauge feeding equipment and trimmers



CONE PAYOFF STRIPPER, FLATTENER AND SHEAR



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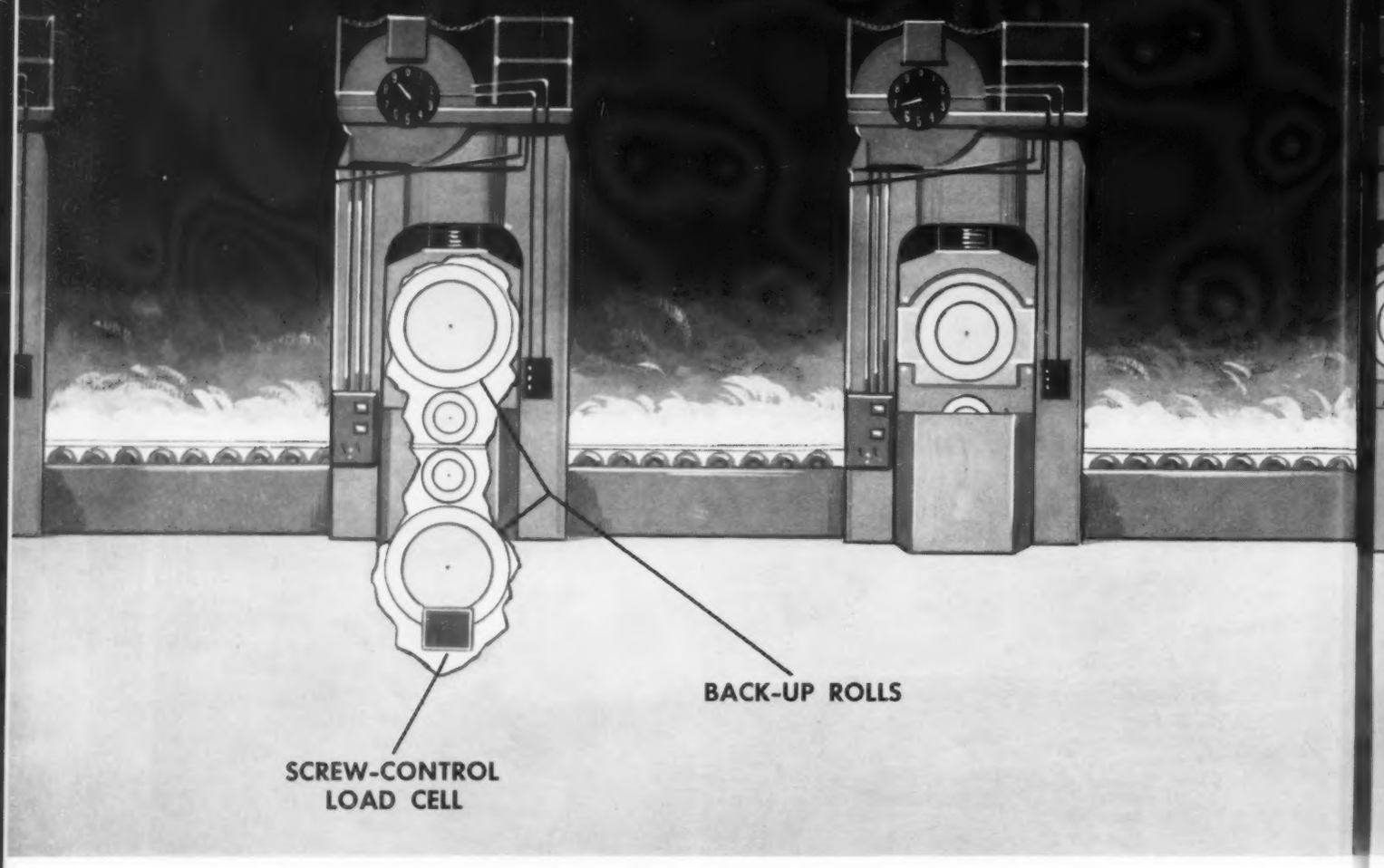
METAL ROLLING
AUTOMATED BY GENERAL ELECTRIC



AT USS GENEVA WORKS

G-E automatic gage control maintains

A new, vastly improved method of automatically controlling gage on hot-strip mills is available now. Greater strip uniformity and increased yield per ton of steel will result from use of this thickness control system, developed jointly with U. S. Steel Corporation engineers, and now installed at USS's Columbia-Geneva Steel Division, Geneva Works, Provo, Utah.

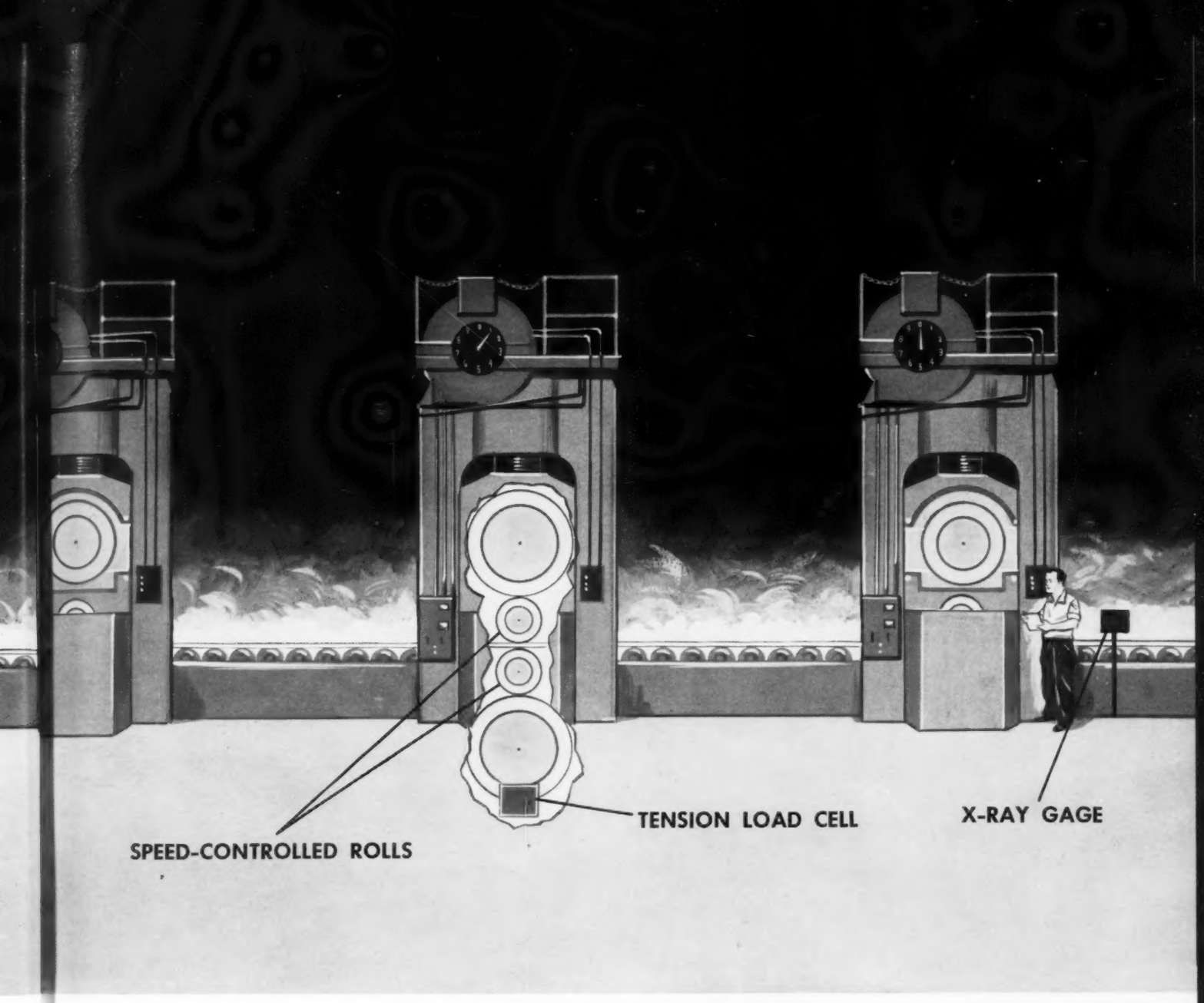
HOW UNIFORMITY AND YIELD ARE CONTROLLED

The system operates on the basis of off-gage steel automatically correcting itself by "triggering" the control to change the roll settings and inter-stand tension. As the temperature or gage of the strip being fed to the mill varies, the pressure against the rolls varies. At the second stand, this change in pressure is detected by the load cell where it is converted into power to move the screwdown motors. This entire operation is completely automatic and is initiated in a fraction of a second.

At the fifth stand, the same detection system is used to recheck the gage of the strip. However, at this point, the correction is made by adjusting the speed of the rolls, rather than their position. This controls the tension of the strip on either side of stand five, depending upon the correction required.

Automatic correction for hot and cold spots—As hot and cold spots pass through the mill, the control "feels" the difference in the hardness of the strip and automatically adjusts inter-stand tension to maintain a constant gage.

Strip "tail" is rolled to gage—The "tail" of the strip is often off-gage as a result of loss of tension as the end of the strip passes through the mill. The gage control



strip uniformity—increases yield

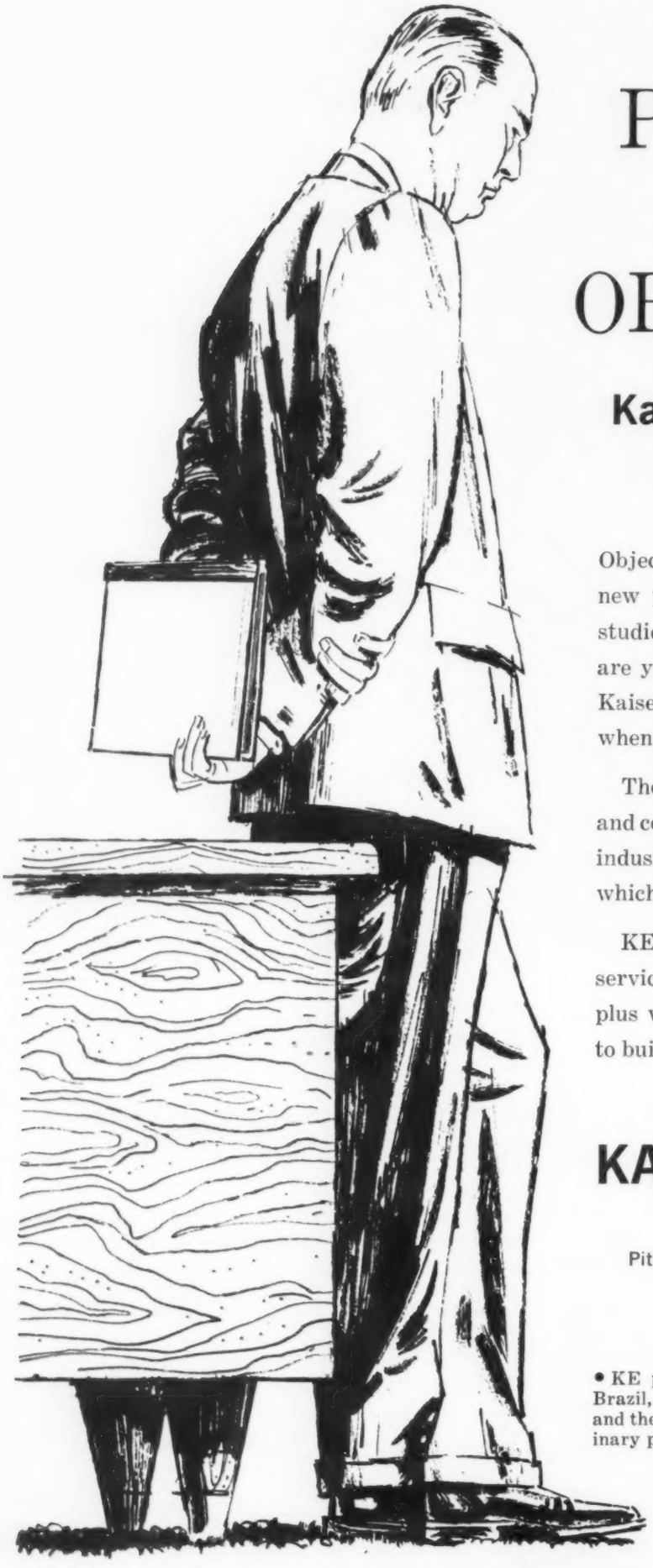
system adjusts the rolls or inter-stand tension to compensate for this loss of tension and rolls the "tail" to closer tolerance thickness, resulting in less scrap and greater yield.

Automatic correction for long-time drift—An x-ray thickness gage is normally used in conjunction with the control. The x-ray continuously measures the gage of the strip, and automatically makes corrections to compensate for thermal effects and mill drift.

For complete details on this new gage control method, contact your G-E Apparatus Sales Engineer today, or write to Section 785-8, General Electric Company, Schenectady, N. Y., for bulletin GEA-6947. Industry Control Department, Roanoke, Virginia.

Progress Is Our Most Important Product

GENERAL ELECTRIC



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KE offers complete, one-company, integrated service from concept through construction—plus world-wide experience and the ingenuity to build quickly, within budget.

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• KE projects include work in Argentina, Australia, Brazil, Formosa, Japan, New Zealand, as well as Canada and the United States. Assignments range from preliminary planning to plant construction.

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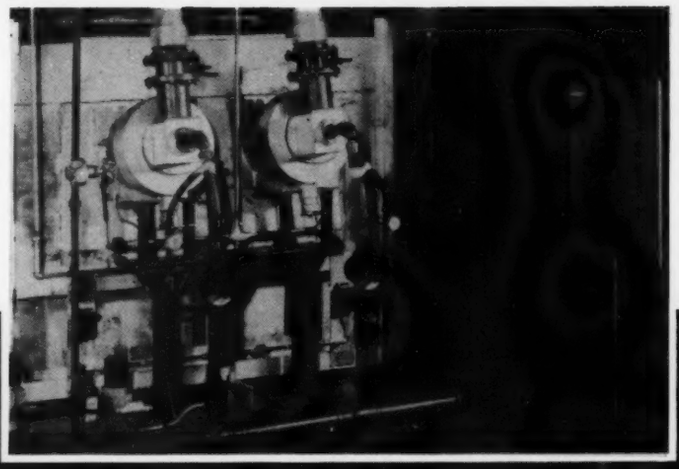
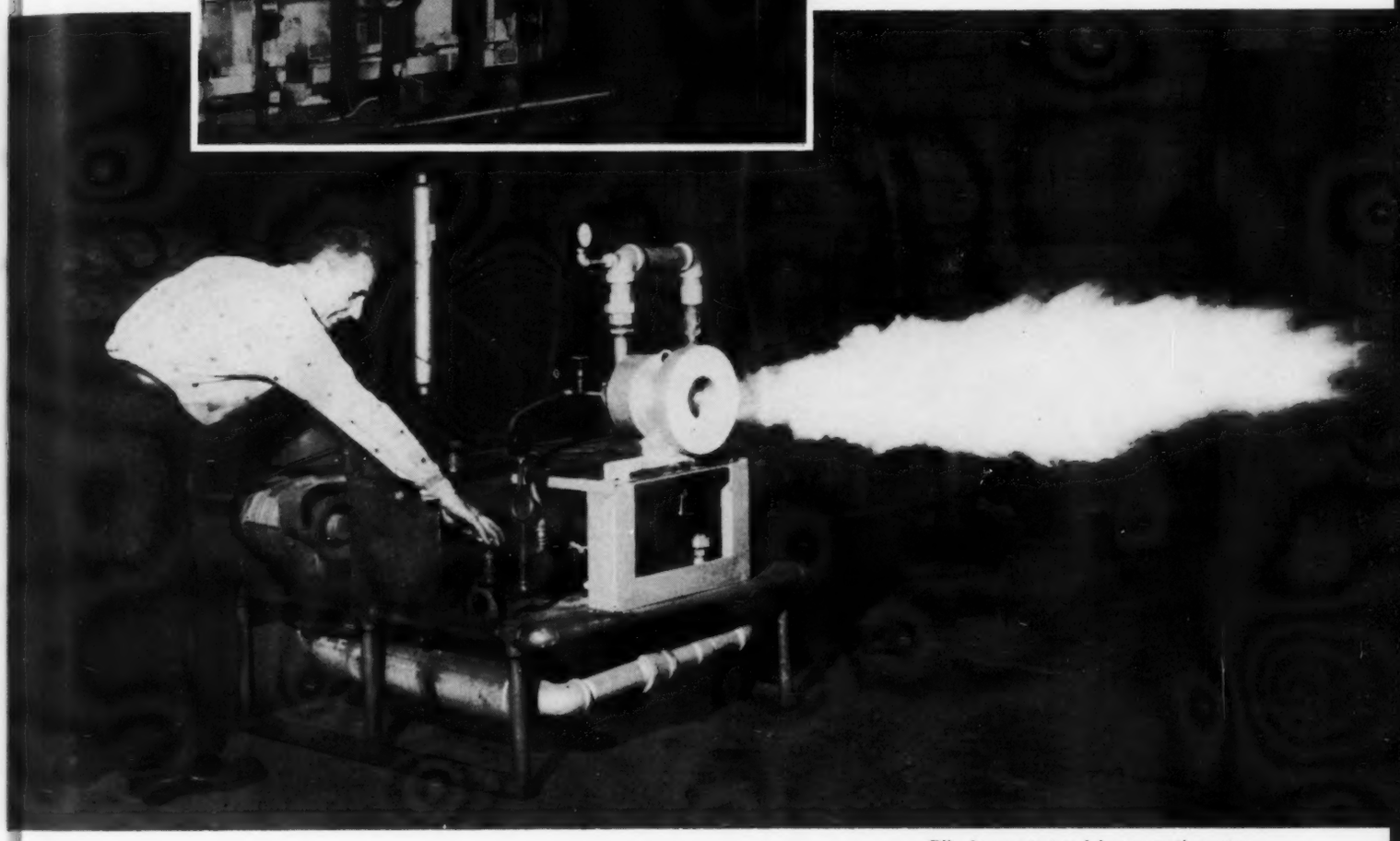


REVERBERATORY FURNACE — CAST IRON . . . *At its Mackintosh-Hemphill Division, Bliss itself uses two No. 5 aspirator burners to melt charges for cast iron mill rolls. Replacing a pulverized coal burner, they eliminated operation and maintenance costs on coal handling equipment. Furnace capacity is 55,000 lbs. Fuel is natural gas.*



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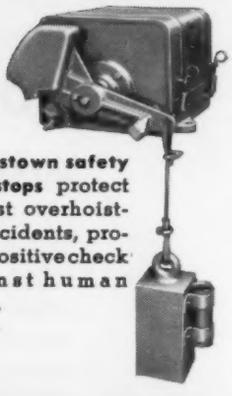

Youngstown safety limit stops protect against overhoisting accidents, provide positive check against human errors.

Write for Bulletins *on any or all EC&M controls. They give complete descriptions of equipment and explain why EC&M control keeps cranes operating at top efficiency. Square D Company, EC&M Division, 4500 Lee Road, Cleveland 28, Ohio.*

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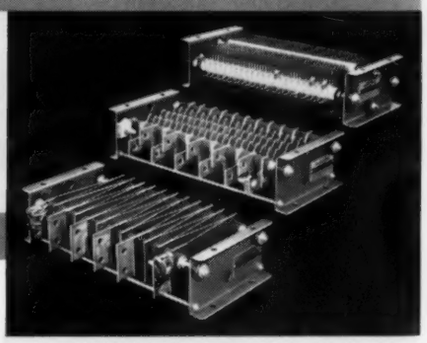
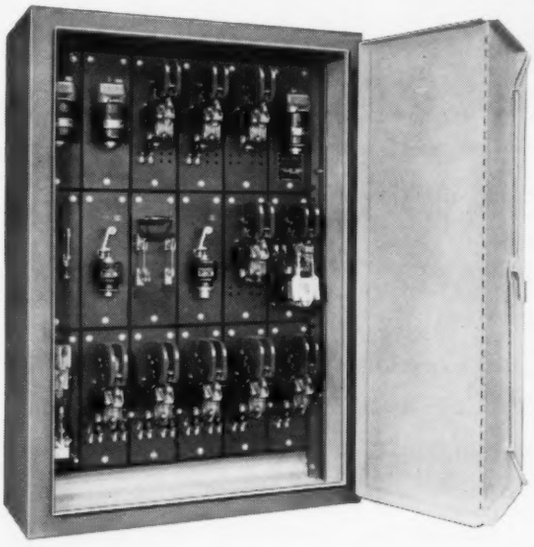
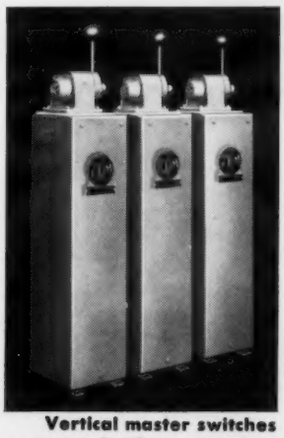


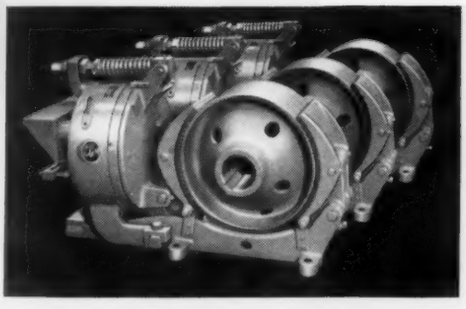
Tab-Weld resistors eliminate burning at the grid eyes or tap plates. Available in capacities from 13 to 500 amperes continuous.

DC controllers are simple to maintain, provide pinpoint accuracy and safe operation.

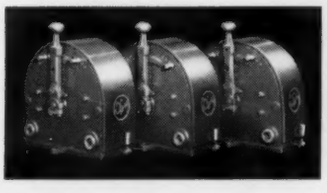




Vertical master switches require little mounting space. Short throw reduces operator fatigue.

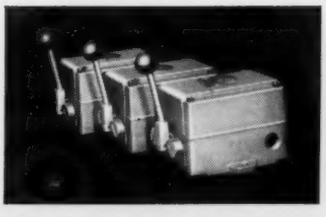


Long-life brakes give high-speed performance, have 100% lubrication so that dirt can be flushed out.



CM master switches have short throw of operating handle and narrow width for close grouping.

Manual-magnetic disconnect switches provide a convenient and quick means of "killing" the crane, including an emergency remote-controlled STOP button.

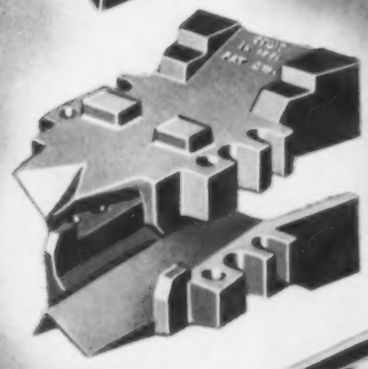


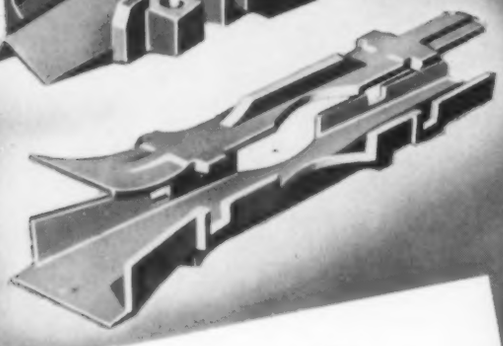
MA master switches provide a maximum of 3 speed points. Can be grouped with other masters or can be used on auxiliary drives.

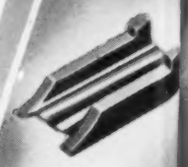
WHEREVER ELECTRICITY IS DISTRIBUTED AND CONTROLLED . . . . .

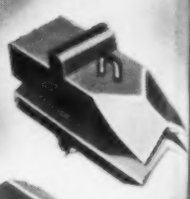
3880

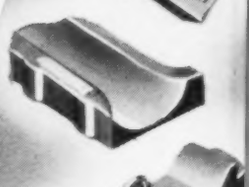
TRANTINYL GUIDES THE STEEL INDUSTRY

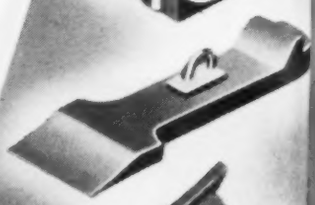


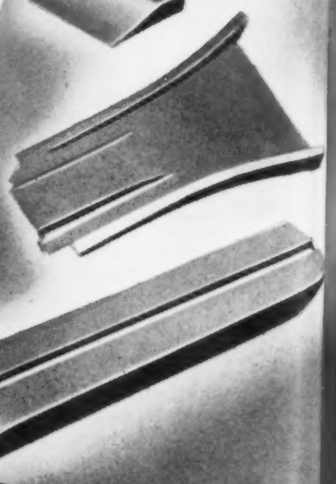












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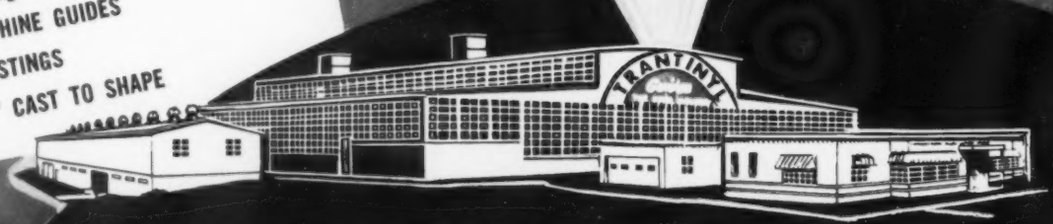
"TRANTINYL No. 1" CAST TO SHAPE



Youngstown Alloy Casting Corporation
Youngstown, Ohio

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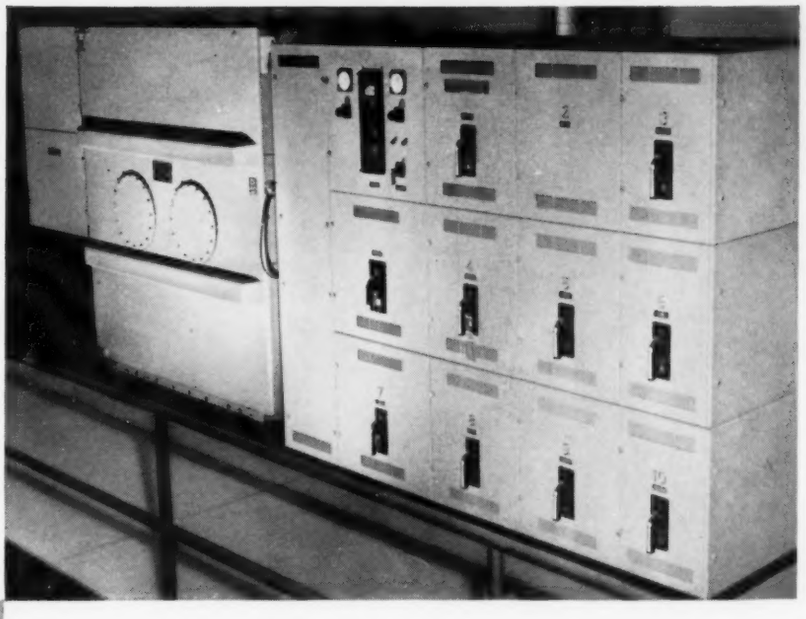
SEALED DRY-TYPE TRANSFORMERS

These modern unit substation transformers can be safely installed in any load-center—any place—because they are hermetically sealed in welded steel cases to provide positive protection from contamination, fire and explosion hazards. The only maintenance needed is periodic checking of gas pressure (inert nitrogen), case and bushings.



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These new quiet-type transformers are compact, light in weight, provide a flexible, modern power system to change higher voltage distribution service to lower voltage lighting and power circuits. They meet all safety requirements for indoor installation.

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Non-inflammable liquid filled. For indoor or outdoor installation. Close-coupled design fits flush against switchgear enclosures, to eliminate and save space. Throat-connected designs are also available.

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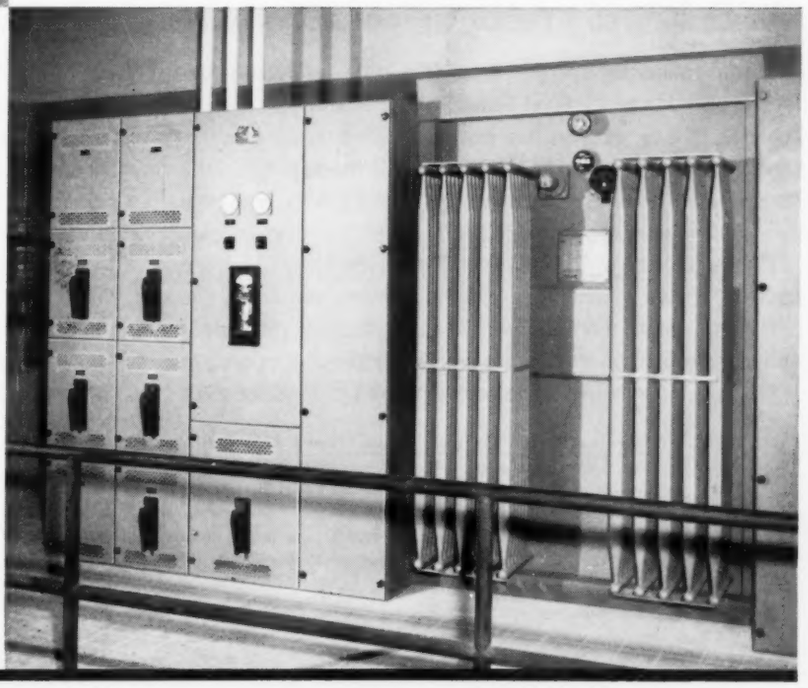
WT59-2



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To Clean Electric Furnace Fumes To 550° F

BETHLEHEM PACIFIC COAST STEEL

SELECTS **THERM-O-FLEX** GLASS FILTERS!

SELECTION MADE AFTER EXTENSIVE PILOT PLANT STUDIES PROVED "THERM-O-FLEX" ADVANTAGES

To insure clean gas emission from two 100 ton electric furnace operations at its West Seattle plant, Bethlehem Pacific Coast Steel Corporation has installed a Western Precipitation "Therm-O-Flex" Hi-Temperature Filter system—*the filter system featuring silicone-treated glass bags that efficiently clean gases as hot as 550°F!*

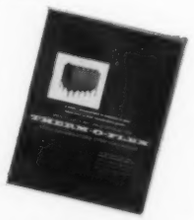
This is the first steel plant installation in the West to use glass bag filters for cleaning electric furnace emissions, the installation being made only after an exhaustive pilot plant study by Bethlehem Pacific engineers. Subsequent operation of the full size installation has clearly substantiated the pilot plant results and has demonstrated the unusually high collection efficiency of "Therm-O-Flex" equipment on this type of application.

No Shaking Required

In addition to their ability to handle unusually hot gases, the specially-treated woven glass filters of the "Therm-O-Flex" permit the filter units to be easily cleaned by simply collapsing the bags. *No destructive shaking processes are required.*

Furthermore, the large diameter filter tubes (12″ in diameter) provide more efficient cleaning of the collected material on each collapsing cycle—another operating advantage engineered into each "Therm-O-Flex" installation by Western Precipitation dust control "know-how."

"Therm-O-Flex" is one of six types of gas cleaning equipment offered by Western Precipitation — *"Cottrell" Electrostatic Precipitators, "Multiclone" Centrifugal Collectors, "CMP" Combination Multiclone-Precipitator units, "Therm-O-Flex" Hi-Temp Filters, "Dualaire" Jet-Cleaned Filters, and "Turbulaire-Doyle" Scrubbers.* No other organization provides such wide range dust collection experience — no other offers such unbiased recommendations to fit the requirements of *your particular* operations. You simplify your gas-cleaning problems by bringing them to Western Precipitation.



Send for "Therm-O-Flex" Bulletin #F105!

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1. COTTRELL Electrical Precipitators
2. MULTICLONE Mechanical Collectors
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4. DUALAIRE Jet-Cleaned Filters
5. THERM-O-FLEX Hi-Temp Filters
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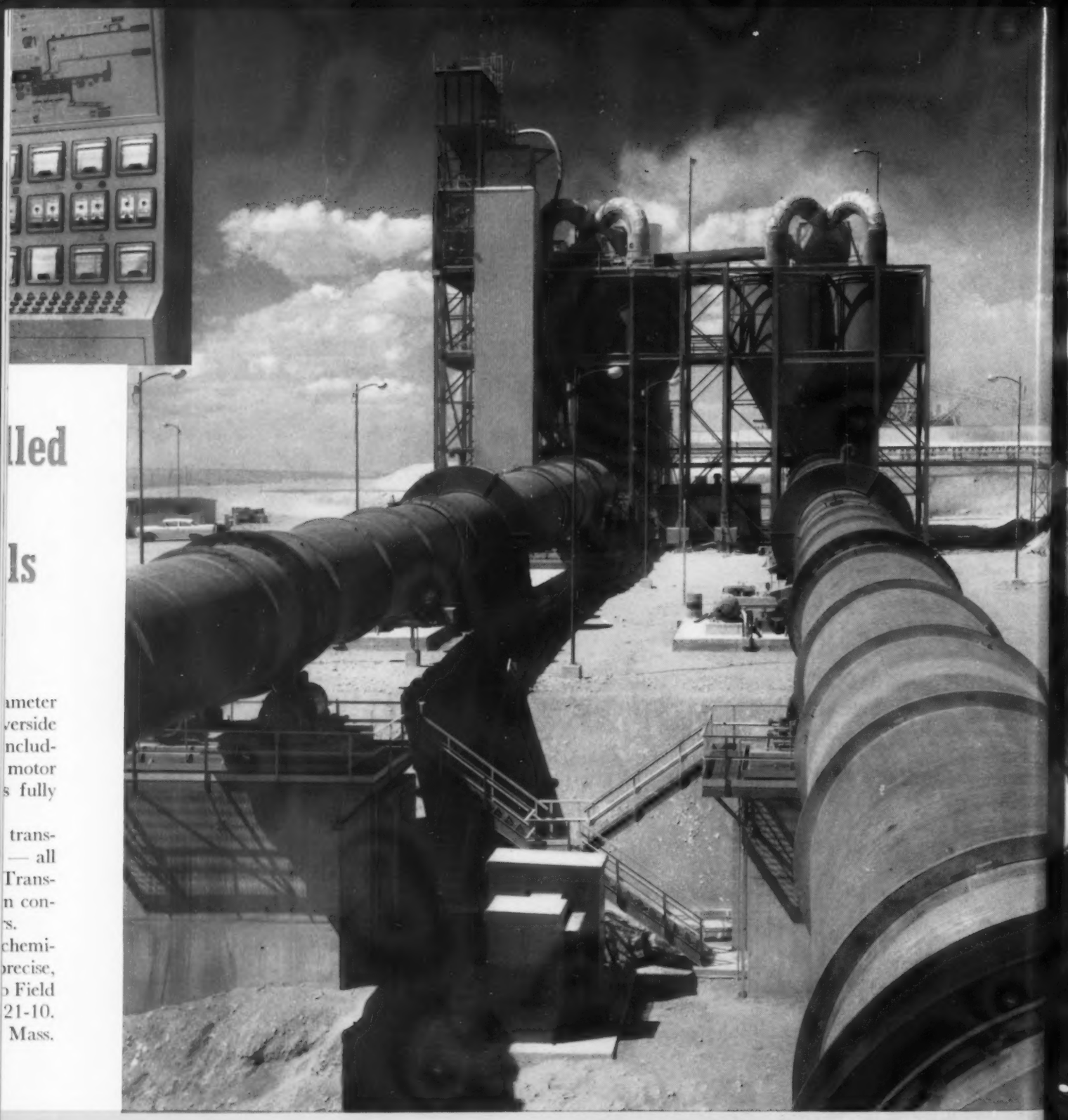

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For measurements such as pressure, absolute pressure, differential pressure, and level. Require no local power supply.

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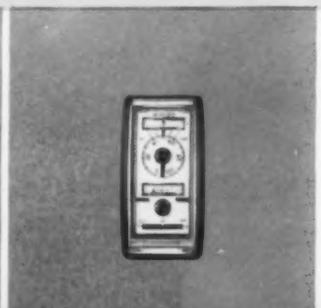
May be mounted individually or in same housing with recorder. Each operates and pulls out from panel — completely independent of the other.

Typical application of Foxboro Electronic Consotrol Instrumentation . . . Riverside Cement Company's modern plant at Oro Grande, Calif. 310′ kilns have all process variables under Foxboro electronic control. Other major Foxboro electronic installations include petrochemical plants in the U. S. and Canada, nuclear reactors, as well as unattended booster stations on a 680-mile crude oil pipe line.



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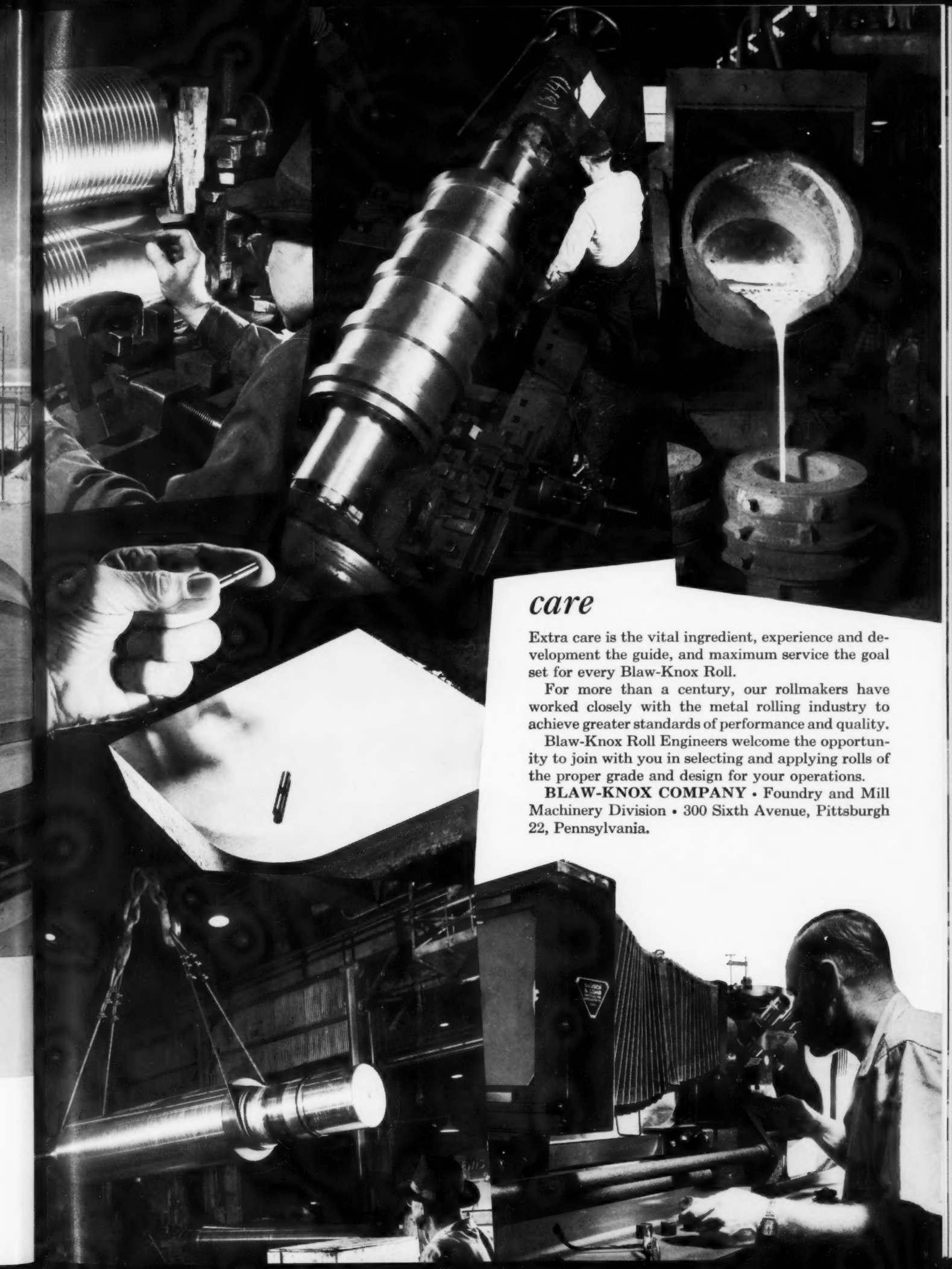

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Extra care is the vital ingredient, experience and development the guide, and maximum service the goal set for every Blaw-Knox Roll.

For more than a century, our rollmakers have worked closely with the metal rolling industry to achieve greater standards of performance and quality.

Blaw-Knox Roll Engineers welcome the opportunity to join with you in selecting and applying rolls of the proper grade and design for your operations.

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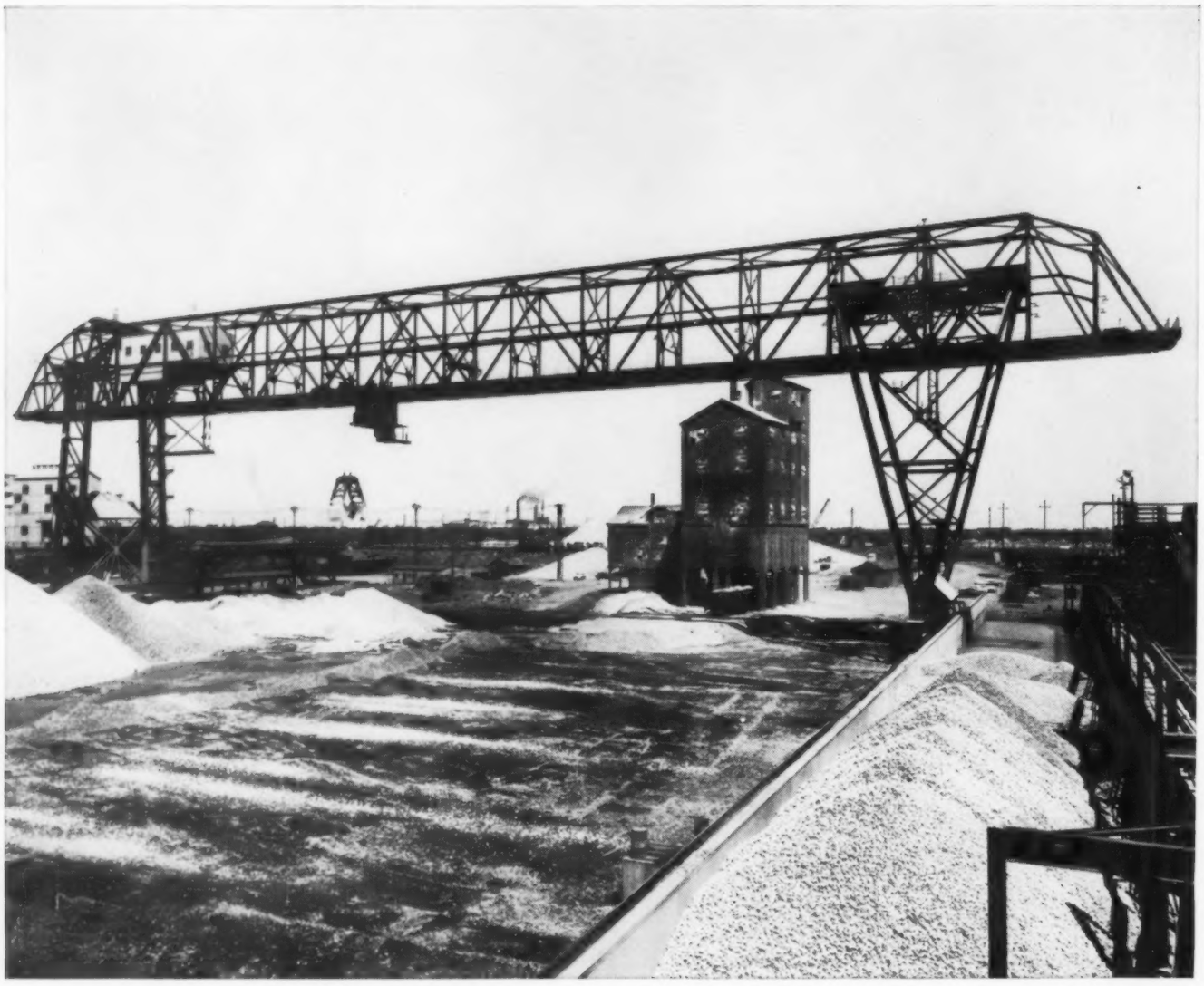

Dravo builds new bridge for Interlake

Bridge stockpiles iron ore at 1,360 gross tons an hour

Built as part of a major dock and ore yard expansion program, a new ore bridge is operating at a free digging rate of 1,360 gross tons an hour at Interlake Iron Corporation's merchant pig iron plant at Chicago.

Great Lakes ore boats are unloaded at a new dock on the Calumet River by a new unloader also built by Dravo. Ore moves by conveyor from dock to storage yard, where the new bridge stockpiles it for loading into transfer cars bound for the blast furnaces.

Built by Dravo under contract to Arthur G. McKee & Company, the new bridge spans 390 feet between the legs and its man-trolley is located 104 feet above the yard. The man-trolley, which can rack back and forth at 1,080 feet per minute, is equipped with a 300-cubic-foot bucket.

Safe man-trolley stops, even in event of accidental over-run, are assured by six-foot stroke hydraulic buffers located at either end of the trolley tracks. Wind protection is provided by Dravo *Gale-Guard* rail clamps which automatically clamp the bridge to the rails when wind velocity reaches 35 mph or when power is shut off.

Find out how Dravo's experience in ore and coal handling equipment can serve you. Write, wire, or telephone: Materials Handling Department, Dravo Corporation, Pittsburgh 25, Pennsylvania.

Towboats, barges, river transportation • slopes, shafts, tunnels • gas & oil pumping stations • ore & coal bridges • pumphouses & intakes • boiler & power plants • heaters • docks & unloaders • fabricated piping • bridge sub-structures • river sand & gravel • sintering plants • mill lubrication systems • locks & dams • process equipment • gantry and floating cranes • mechanical construction • marine repairs foundations • vibrating screens & conveyors • ready-mixed concrete • dredging • pile driving • grating

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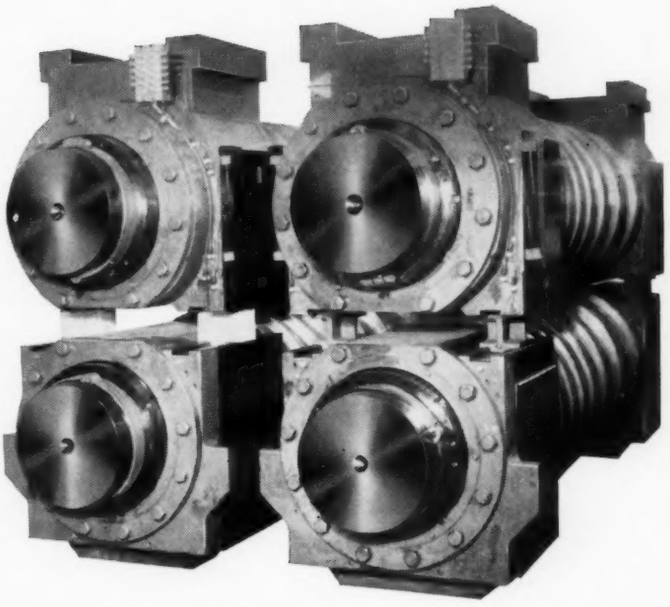
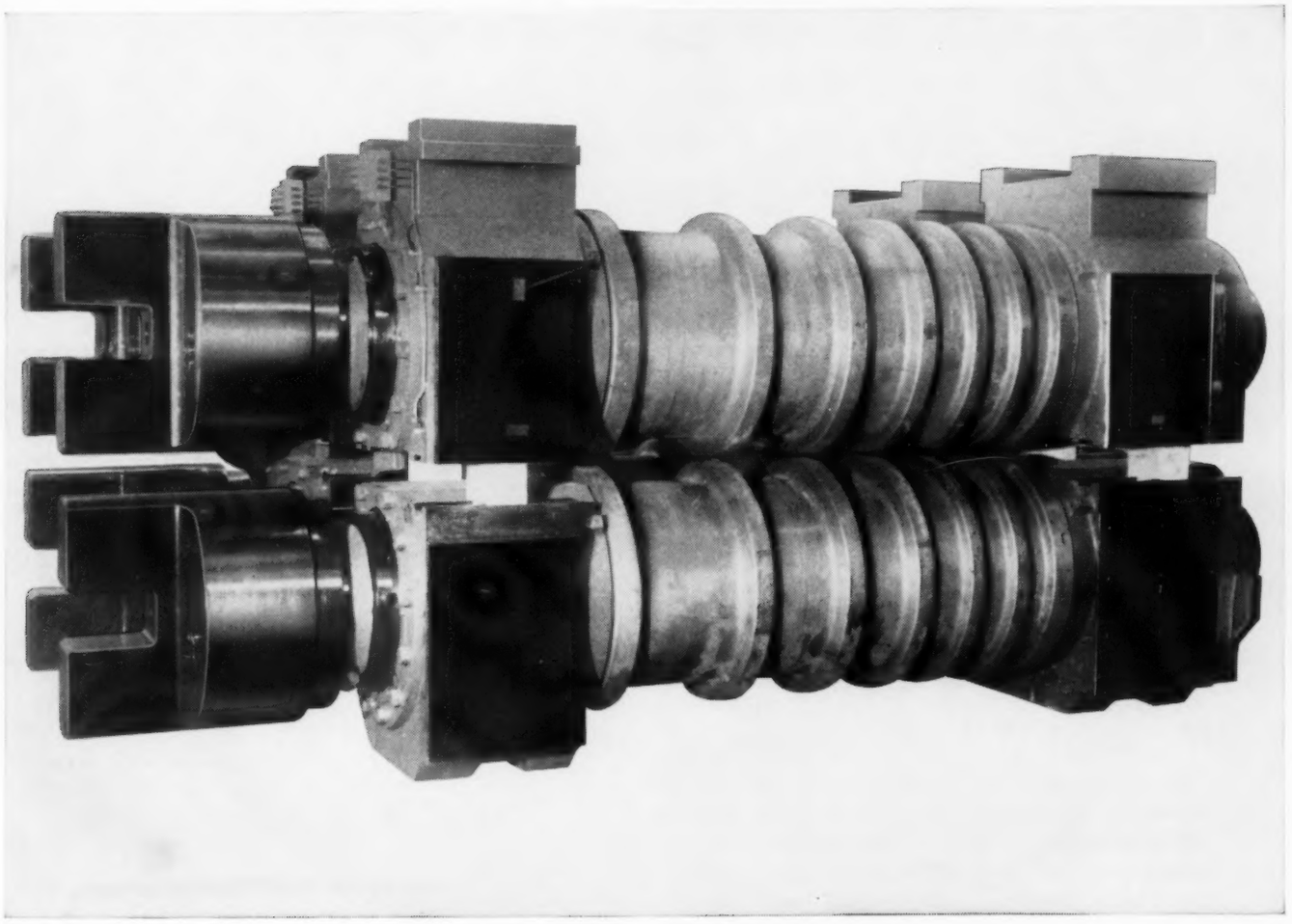


• another set of thoroughbreds—this time for one of America's largest steel producers . . . ready to carry a top production load. BIRDSBORO "breeding" starts way back in the laboratory, where advanced research results in a specialized family of rolls to meet the toughest mill requirements. BIRDSBORO rolls are favorites in all production races . . . and they can be real profit winners for you. *Sales Department, Engineering Department and Mfg. Plant:* Birdsboro, Pa., *District Office:* Pittsburgh, Pa.



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STEEL MILL MACHINERY • HYDRAULIC PRESSES • CRUSHING MACHINERY • SPECIAL MACHINERY • STEEL CASTINGS • Weldments "CAST-WELD" Design • ROLLS: Steel, Alloy Iron, Alloy Steel

Mobilplex ep

The Multi-Service Grease with unique Calcium EP Complex. Never before in a single lubricant such a wide range of use...such a margin of superiority...such a potential for maintenance savings!

Outstanding resistance to the washing action of water and emulsions is one of the many important properties of Mobil's new Multi-Service Grease—*Mobilplex EP*. In your steel mill you'll find it ideal for work-roll bearings and hot mill run-out-table bearings. Mobilplex EP also offers good pumpability at low temperatures, low feed rates, outstanding resistance to heat in the range of 300 F, extra protection against wear and rust. It is a singularly tenacious and adhesive lubricant.

This multi-service grease has outstanding oxidation resistance as well as excellent storage and structural stability. These qualities, plus the great versatility of Mobilplex EP, make it useful throughout the steel mill.

Mill operators in every section of the country are finding Mobilplex EP extremely effective in extending bearing life and protecting production schedules. In addition, they're saving more than with ordinary multi-purpose greases because Mobilplex EP makes it possible to reduce application frequency, simplify storage and handling procedures.

Contact your Mobil representative for full details. He can show you results of laboratory performance tests of Mobilplex EP and five competitive extreme-pressure greases. You'll see why Mobilplex EP is rated tops!

MULTI-SERVICE ABILITY OF MOBILPLEX EP

ANTI-FRICTION BEARINGS (*horizontal and vertical*). Temperatures in the range of 300 F. Heavy or shock loads. Water contamination. Speeds—low, normal, high.

PLAIN BEARINGS All normal mechanical and operating conditions. Temperatures in the range of 300 F. Waterwash. Heavy or shock loads.

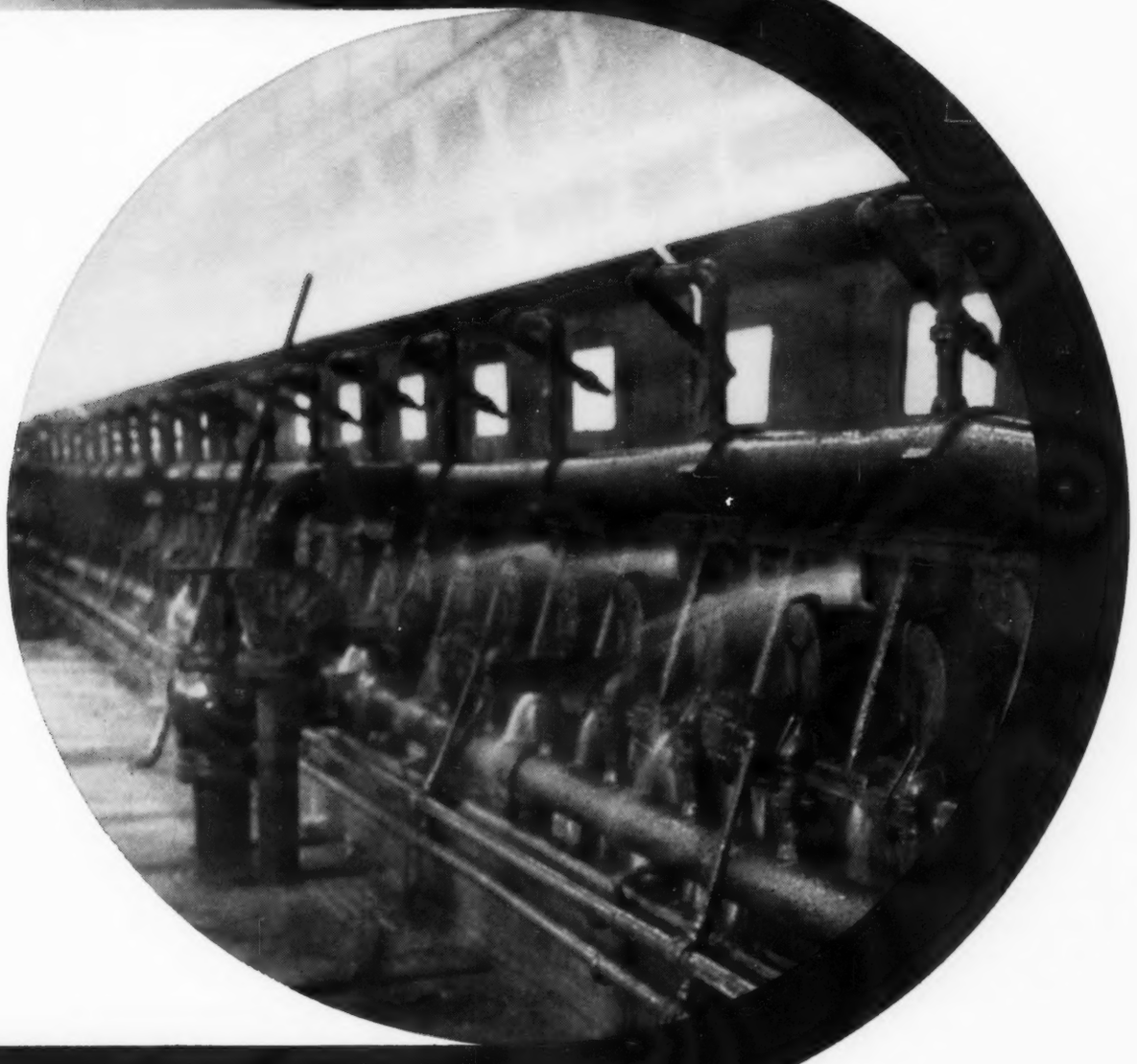
DISPENSING AND APPLICATION DEVICES
Transfer pumps. Hand and power guns (*long lines*). Central greasing systems.

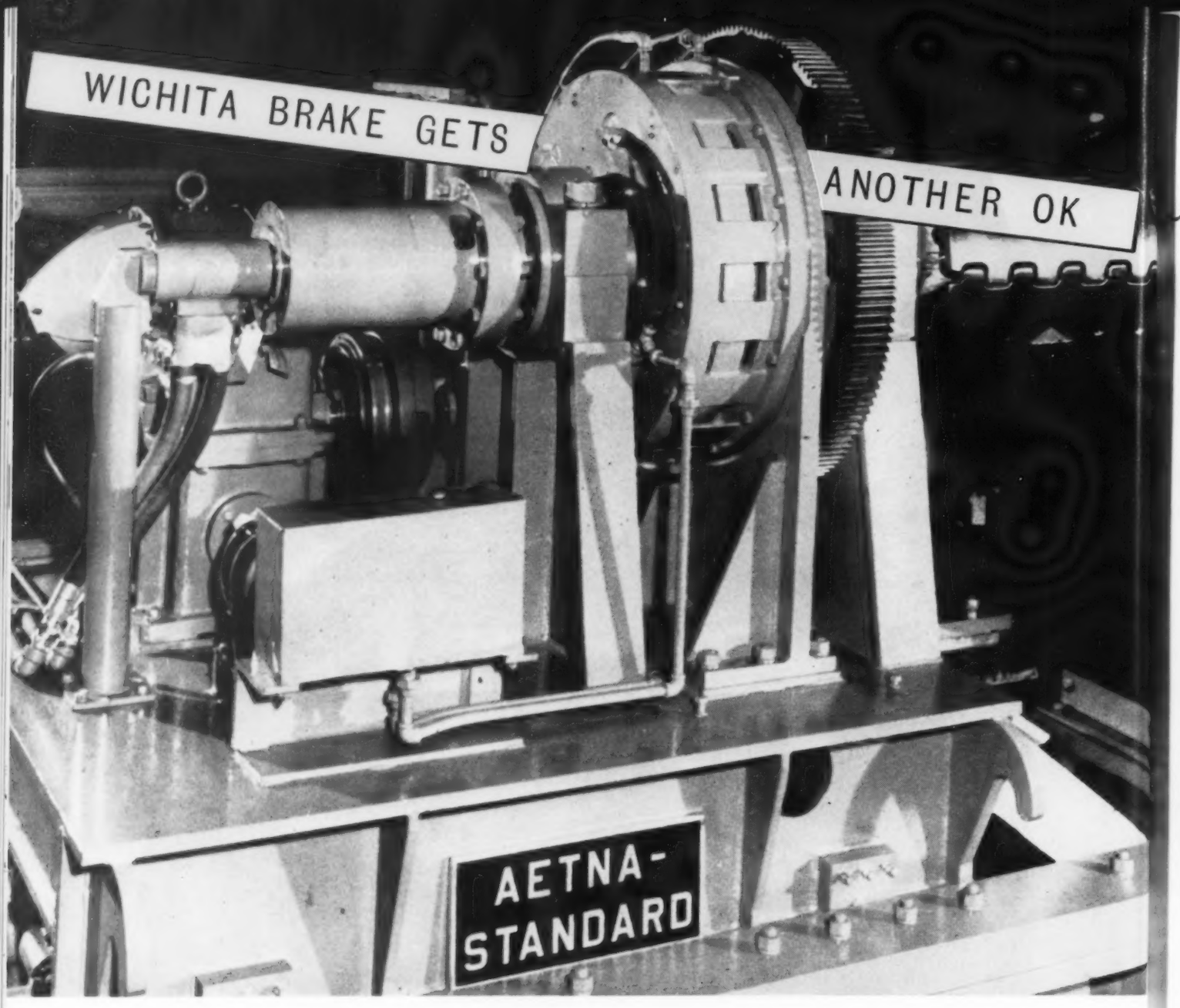
Mobil

Proved Petroleum Products... Available with a Mobil Program of Correct Lubrication

Left: Bearings packed with Mobilplex EP are unaffected by the direct washing action of water . . . rust and wear are avoided.

Below: Like other steel-mill bearings exposed to water and emulsions, hot mill run-out-table bearings stand up longer with Mobilplex EP.





"Most satisfactory brake from a cost and performance basis," says Aetna Standard

The Aetna Standard Pay Off Reel pictured above is equipped with a Wichita Water Cooled Drag Brake . . . selected to perform the work required. Better performance inherent in Wichita designs are helping quality equipment manufacturers like Aetna Standard, solve tough braking or clutching problems.

A Wichita Engineer will be happy to work with your engineering and sales department to help you find the most profitable solution.

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Foreign Digests

Complete translations from which these condensations were prepared are available from Henry Brutcher, P.O. Box 157, Altadena, Calif., to whom all correspondence should be addressed.

"DUST REMOVAL AT THE BOCHUMER VEREIN LD STEELWORKS

by R. HARR, K. WAGNER and T-H. WILLMER (Translation No. 4646 from Berg- und Huttenmänn. Monatshefte, vol. 104, 1959, No. 2, pages 50–55)

△ THE new Bochumer Verein steelworks was faced with the problem of eliminating dust from LD converters. Since, no large quantities of surface water were available, cooling and cleaning had to be done with minimum water usage.

Gases leave the LD crucible at above 3200 F. They must be cooled before being cleaned, and this is done with a waste heat boiler. The steam produced at a maximum of about 780 psi is unfortunately at present useless, since it is not produced continuously and there is no steam consumer at Hontrop. It is at present condensed in a condensation plant and the condensate returned to the boiler. Future plans point toward a later power plant which will operate on steam from the hot waste gases from open-hearth furnaces and also the periodic supplies of steam from the LD heats.

The cooled gas is cleaned in a saturator, a venturi tube and a separator.

In washing out the dust in the venturi scrubber it is not sufficient to spray in a certain quantity of water, because the size of the dust particles is too small for them to be wetted. To get a good effect the gas must be brought to a speed of 330 fps and over in a venturi tube and a water mist must cross the path of the gas at right angles. Also for wetting the extremely fine smoke particles, there is nothing better than recycled water, that is used water containing dust.

Dust from the LD vessel varies in size; 10 per cent of it is over 0.0024 in. and 90 per cent below this, down to particles less than 0.0004 in. In the saturator the injected water traps all the coarse dust and the fine dust is trapped in the venturi tube. About 15 to 20 per cent of all the dust is trapped in the saturator, and 85 to 80 per cent in the venturi tube.

"WASTE HEAT RECOVERY AT THE LD STEELWORKS IN DONAWITZ"

by A. VACEK (Translation No. 4644 from Berg- und Huttenmännische Monatshefte, vol. 104)

△ WHEN the LD steelworks started operation at Donawitz, authorities protested very strongly against the discharge of dust into surrounding air. There was not at that time any useful information on the subject. To find out in what directions to proceed, a series of experiments was carried out indicating that the electrostatic precipitator was the best of the dry systems.

The precondition for any economic dust removal, in a dry or a wet system, is the cooling of the crucible gases from 3270 to 570 to 660 F. Also, the heat given out ought to be recovered, since for a heat of about 30 tons it works out at about 34,000,000 Btu.

A waste-heat boiler with forced circulation tube system and a steam drum outside the heating system was installed common to both vessels, capable of being switched to whichever was in operation at the time. This boiler feeds into the plant steam system.

A number of measures were adopted to make the steam system flexible. The first part of the steam surge from the LD boiler is fed into an accumulator, connected through a hot water storage vessel with the general hot water system of the works.

OTHER AVAILABLE TRANSLATIONS

"Waste Heat Boiler Systems and Gas Cleaning Plants Downstream of LD Vessels and Converters," by H. Rasworschegg, Berg- und Hüttenm. Monatshefte, vol. 104, 1959. Report on installation of waste-heat boiler plants downstream of LD oxygen process vessels and bottom-blown converters for complete elimination of brown fumes by wet mechanical methods, either alone or combined with wet electrofilters, with scarcely any increase in investment cost of the steelworks. Waste-heat boilers for LD vessels; variation of steam supply during blows. Boiler design. Waste-heat boilers erected in Japan, Germany, Austria; originally to ensure suitably low outlet temperatures for gas cleaning plants and now for providing principal power and heat to steelworks. Operating experiences gained. Gas cleaning plants; design for Austrian installation. Present state of dust precipitation; installations able to deliver gas cleaned to 50 to 90 mg/std cu meter and now serving in Austria, Ger-

many and Japan. Waste heat boilers and gas-cleaning plants for bottom-blown converters. (Translation No. 4645)

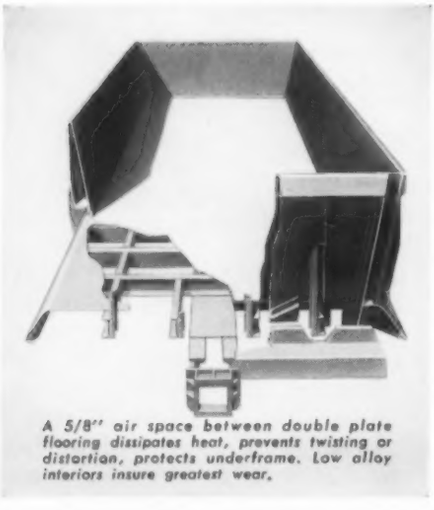
"Operating Experience in the Vacuum Treatment of Open-Hearth Steels," by C. H. Pottgiesser, H-J. Daermann and A. Drevermann, Stahl und Eisen, vol. 79, 1959, No. 8. Use of vacuum-lifter installation at the plant; design of degassing setup. Progress of vacuum treatment with time. Heat losses in ladle; heating system to compensate for them. Difficulties encountered with refractory linings of vacuum vessel, especially suction nozzle, and how they were overcome. Bottom life of degassing tank. Capacity of degassing tank increased from 6 to 12 tons, for improved degassing efficiency. Operating results. Hydrogen content in forgings; comparative oxygen contents of forgings of vacuum-treated and of untreated steel; residual oxides in unalloyed 40-ton ingots with and without vacuum treatment. Casting in controlled atmosphere; effect on oxygen contents. Inclusion content of heavy forging ingots across their section. Results of ultrasonic testing of ships' plates rolled from 21-ton slab ingots. (Translation No. 4603)

"Improvement of Ingot Structure by Vibration of Solidifying Steel," by A. A. Romanov and P. V. Umrikhin Izv. Vuz, Chern. Metall., July, 1958. Experimental confirmation of theoretical predictions about effect of vibration of steel ingots on their structure. Nature of action of motion on solidification. Description of apparatus: vibration platform originally used. Compositions of rimmed and killed carbon steels, and alloy steels studied. Deformation and viscosity of liquid steel as important factors in vibrating. Vibrational acceleration in relation to gravity for steel and gray iron. Effectiveness of degassing action shown on transformer steel. Possibility of producing a compact sound shell of practically any thickness on ingots. Change in nature of segregation across ingot section. Densification of core zone by vibration, resulting in improved hot workability. Grain refinement; elimination of nonuniformity of crystal structure. Explanation of streaks of segregate in vibrated viscous steel. Best vibrating conditions (cycles per minute, and amplitude) for ingots of up to 450 lb. (Translation No. 4610)

"On the Technology of Vacuum Melting of Metals and Alloys," Practical Use of Vacuum Furnace for Refractory Metals, by A. V. Emyashev. 'Primenenie Vakuuma v Metallurgii Moscow 1958. Review of Russian vacuum melting equipment; its drawbacks and how they were eliminated. Data on a 110-lb furnace for melting steel in high vacuum; design; vacuum system. Operation of furnace: rapid evacuation; maintenance of vacuum during heats. Development of a method for making high-grade melting crucibles directly in furnace. Performance of various refractories such as rammed magnesite; prefired alumina and beryllia; technical zirconia; zirconia remelted in an arc furnace. Technique of making crucibles; their appearance when finished and after 43 melts. Temperature measurements in vacuum heats; taking samples: device developed by author; way in which any hanging of the charge in the furnace is avoided. (Translation No. 4635)

MAGOR AIR DUMP CARS

FOR STEEL PLANT SERVICE



A 5/8" air space between double plate flooring dissipates heat, prevents twisting or distortion, protects underframe. Low alloy interiors insure greatest wear.

The new Magor Air Dump Car for steel plant service can cut your refuse disposal costs as much as 40%! Safe, swift, automatic dumping eliminates expensive labor and crane equipment. Low height and open type body means faster loading. Saves time, labor and haulage costs! Smooth interiors eliminate "dead load" returns!

The double-plate flooring shown here is just one of the many Magor design features that account for Magor's leadership in dump car production. Designed for the job — built to last, Magor Air Dump Cars cost less to buy — less to operate!

Savings effected by the new Magor Air Dump Cars will write off your entire dump car investment within a few years.

MAGOR

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MAGOR CAR CORPORATION

50 Church Street
New York 7, N.Y.

TWELVE OF THESE MASSIVE 200-ton soaking pits, among the largest ever built, have been installed at Lukens Steel Co., Coatesville, Pa., to handle a wide variety of specialty steels. To maintain exact furnace

P.S.

To a News Item

This news item which appeared in the PITTSBURGH PRESS concerned the twelve soaking pits recently built in the plant of Lukens Steel Company at Coatesville, Pa. It gave RAMTITE an unintended pat on the back!

How RAMTITE® Got Into This Picture—

There's a RAMTITE product for practically every refractory need. A sales engineer will study your problems and make recommendations or suggestions to your Engineering, Mason and Ceramic Departments.

Please contact your local or nearby RAMTITE representative or write us via letter or the handy coupon below.

You can't see RAMTITE, but it's there — in all the twelve covers of these new soaking pits. These pits are now reheating ingots weighing up to 75 tons each, such as that shown at white heat in the photograph. Temperatures are being kept as high as 2350° F.

RAMTITE was selected for these soaking pit covers because of previous performance in the Lukens plant. ("*The best sign of satisfaction is a repeat order.*") Back of these plastic and castable refractories are 40 years of experience in research and manufacture — in design, construction and installation of the products.

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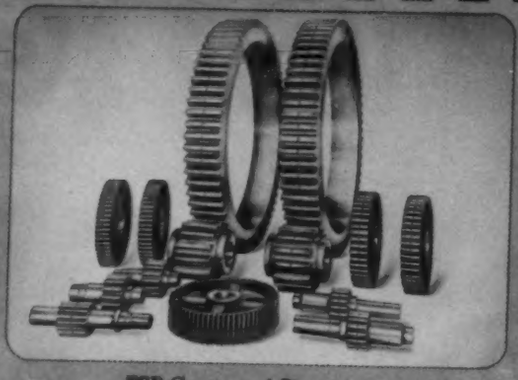
TSP

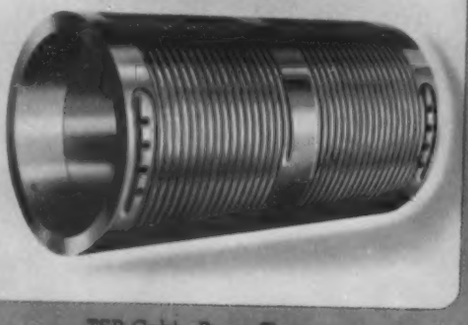
rollin' along with ARMCO since 1911

TSP Rolls, Racks, Eccentric Pinions, Anti-backlash Pinions, Herringbone Drive Gears, Clutches, Clutch Shafts used on Hallden flying shear.

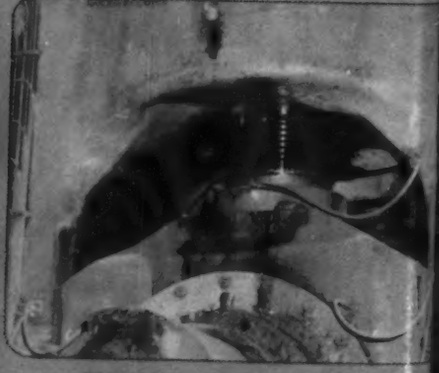


TSP Gears and Pinions on overhead cranes.

TSP Knives, Pinch Rolls, Leveller Rolls on slitting shear.



TSP Cable Drum Sleeves on 25 ton mill cranes.



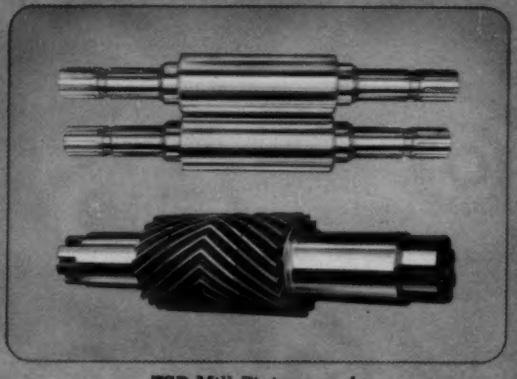
TSP Screwdown Screws and Nuts on 54" hot strip mill.

TSP Rolls and Gears
on levellers.

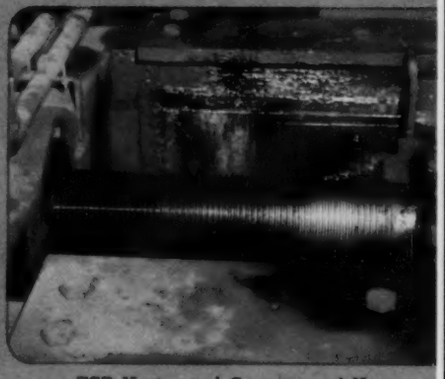
"Tool Steel Process" hardened products are widely used throughout the Armco Steel Corporation's new Butler, Pennsylvania, Works where they help save thousands of dollars in maintenance, replacement and downtime costs.

TSP Work, Back-up, and Intermediate
Rolls on Sendzimir Mill

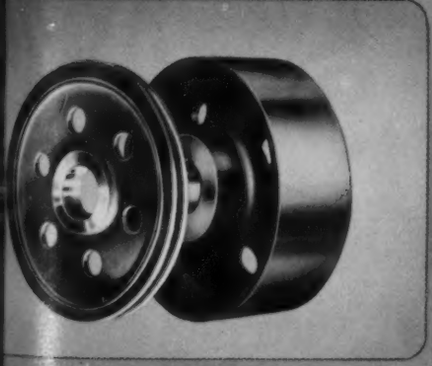
TSP products are hardened by a special process. The file-hard surface to full depth of permissible wear gives maximum life. The core, refined for toughness and ductility, gives maximum strength.



TSP Mill Pinions and
Cold Rolling Rolls.



TSP Horizontal Screws and Nuts
on 54" hot strip mill.



TSP Sheave Wheels
and Brake Wheels.

THE TOOL STEEL GEAR AND PINION CO.

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The Standard of Quality Since 1909 for Gears • Pinions
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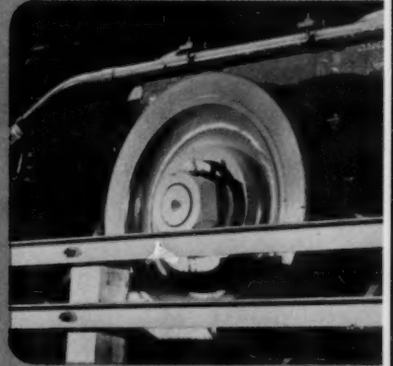
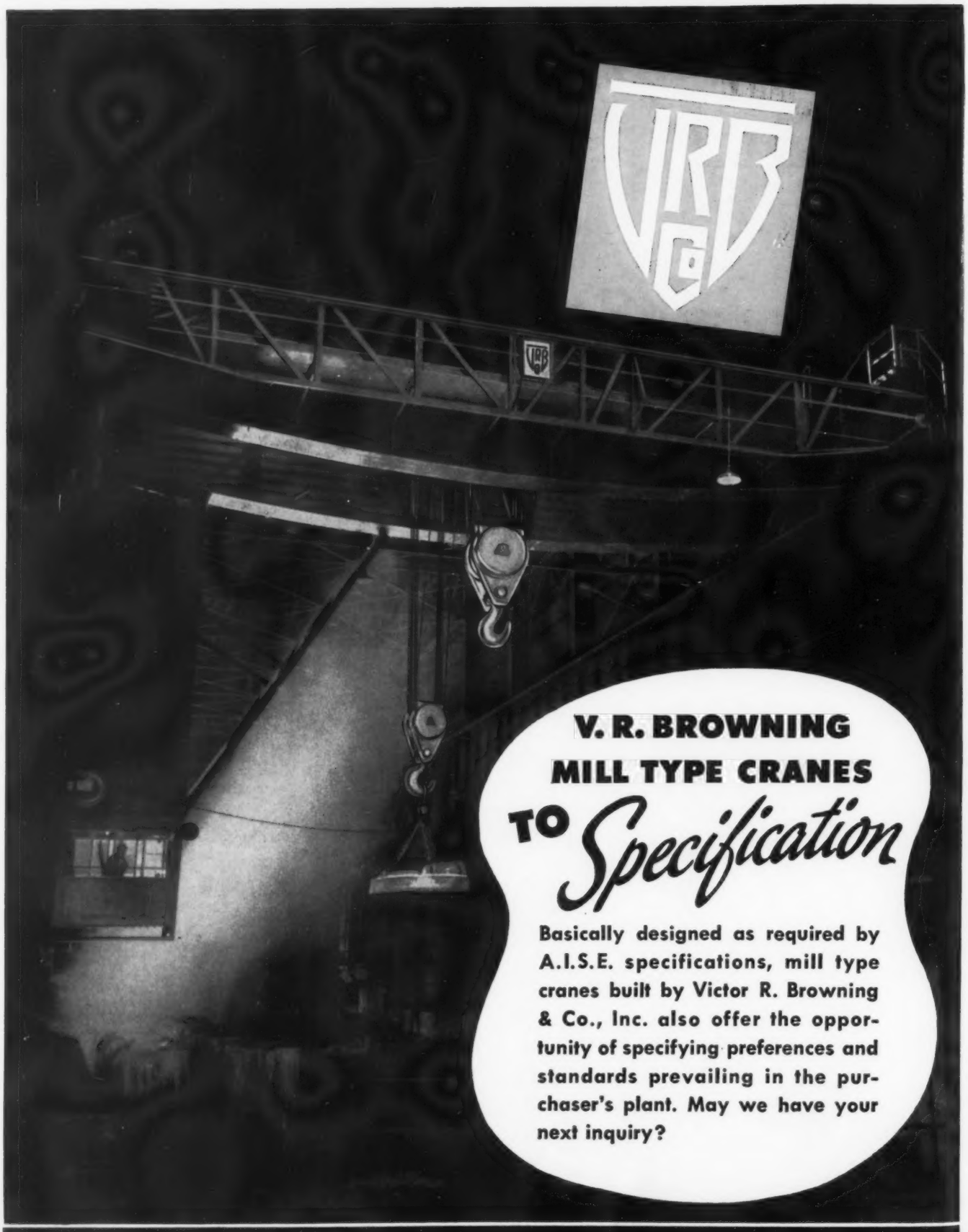


TSP Wheels on overhead cranes.

AD 1037—Printed in U. S. A.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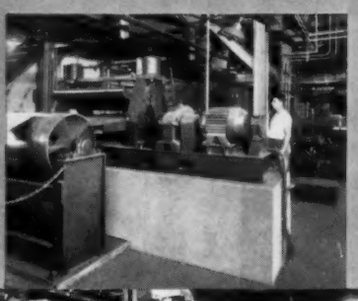
TO Specification
Basically designed as required by A.I.S.E. specifications, mill type cranes built by Victor R. Browning & Co., Inc. also offer the opportunity of specifying preferences and standards prevailing in the purchaser's plant. May we have your next inquiry?

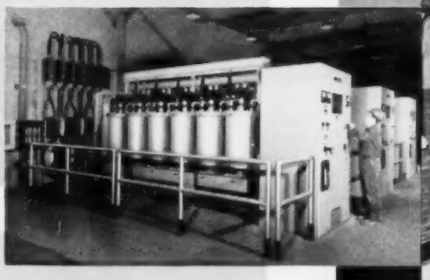
VICTOR R. BROWNING & COMPANY, Inc.
BOX 309, WILLOUGHBY (CLEVELAND), OHIO
Designers and Builders of Electric Overhead Traveling Cranes and Hoists and Electric Revolving Cranes

ALLIS-CHALMERS...in step with **STEEL**

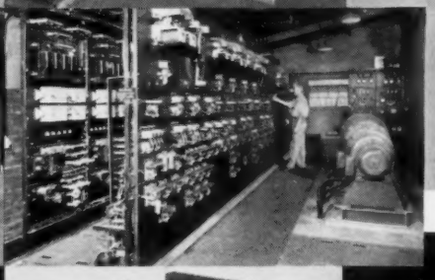
complete electrical systems coordination by Allis-Chalmers:



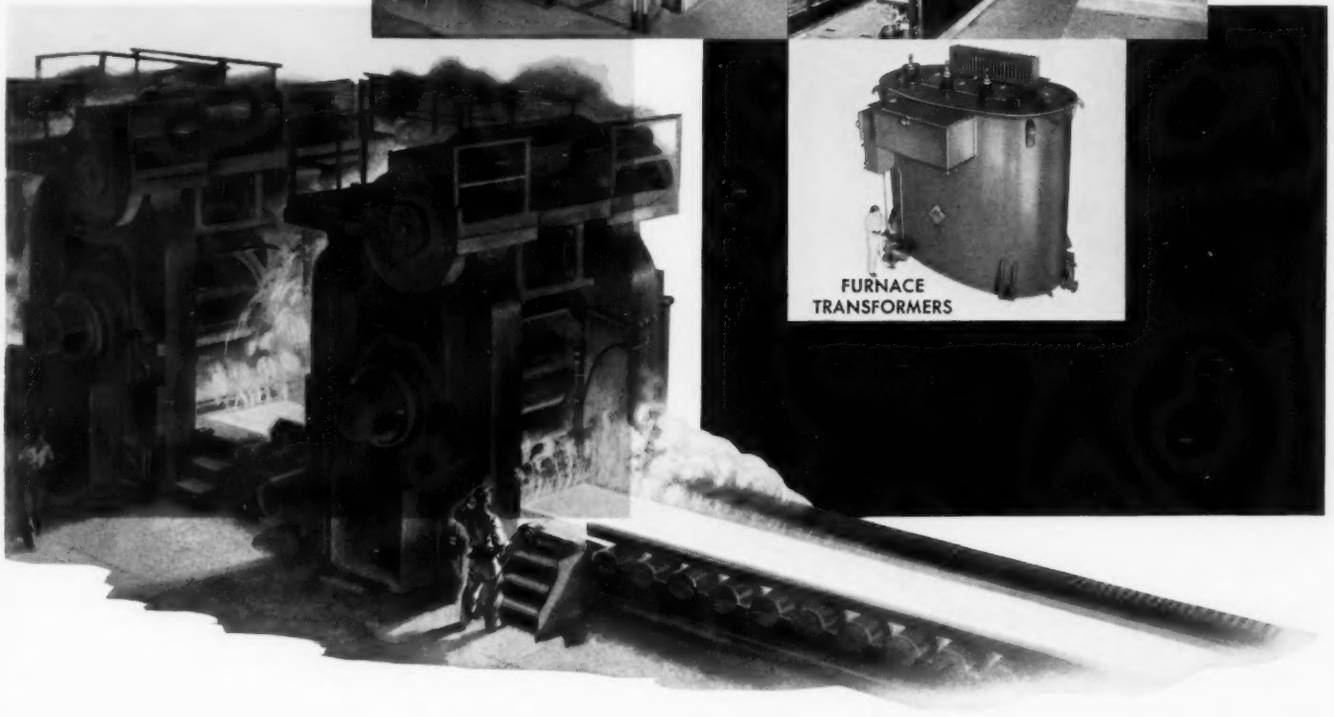
MOTORS



MERCURY ARC & SEMI-CONDUCTOR RECTIFIERS



CONTROLS



FURNACE TRANSFORMERS

single engineering responsibility... superior end results

Planning to modernize, expand or erect new mill facilities? You'll achieve better end results, more efficient operations with the Allis-Chalmers *coordinated* electrical equipment program.

A-C steel mill specialists submit a *complete* proposal package — from system engineering, product application and installation to operation and service. One-source savings are substantial. Operation is *guaranteed*. Call in the engineering expert that *knows* electricity — Allis-Chalmers.

Your nearby A-C representative will assist you with preliminary electrical planning help. He'll show you how A-C integrates the equipment illustrated on the following pages.

ALLIS-CHALMERS

A-1169-IS

This Man Can Help You Get More Efficiency From Plant Equipment

Efficiency is what you want from your plant equipment, and the Dowell engineer can help you get it. Plants in every major industry—for example, oil refining, chemical, public utility, steel and paper—are getting productive results from *economical* chemical cleaning by Dowell.

To remove scale and sludge from your process equipment, boilers, tanks and piping, Dowell engineers provide knowledge and tools you can get from no other chemical cleaning service. You get cleaning knowledge gained from developing and working with the rigorous cleaning standards of the missile program at Cape Canaveral. You get new tools and chemicals from a continuous research program. For example, Dowell recently introduced a new high-velocity jetting device for cleaning tube bundles.

And you get 20 years' worth of experience in all types of industry from Maine to California. Plant operators find it pays to call Dowell on even the smallest job. But they also know that Dowell has the manpower and equipment to clean the largest and most complex systems.

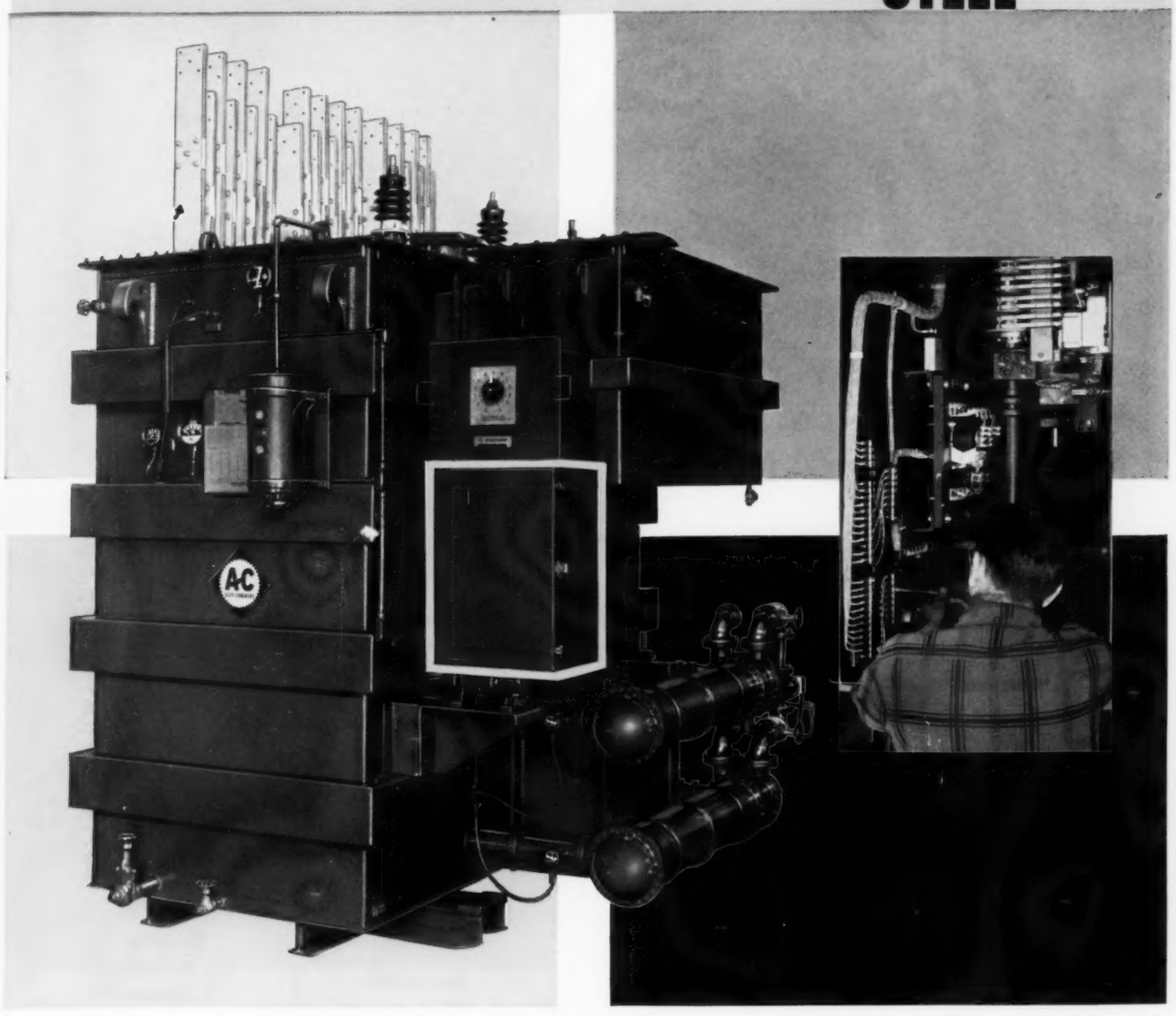
The Dowell engineer takes pride in doing your job so well that you will continue to call him for your cleaning work. This desire to do your job well covers every facet of service—from seeing that you get solvents exactly as specified, to supervising Dowell's full-time safety program. Every precaution is used to protect your personnel and equipment.

Prompt service and detailed information is yours from any of the 165 Dowell stations and offices. Get more efficiency—economically—with the help of the largest, the oldest, the most experienced chemical cleaning service—Dowell, Tulsa 1, Oklahoma.

Chemical cleaning service for all industry DOWELL

DIVISION OF THE DOW CHEMICAL COMPANY

ALLIS-CHALMERS . . . in step with **STEEL**



How Allis-Chalmers transformers make tap sequence changing the quickest job about the furnace

They do it with SELECTOHEAT control! It's the exclusive Allis-Chalmers feature that makes tap sequence changing a matter of minutes —that converts a job which once involved hours of time into the quickest function about the furnace.

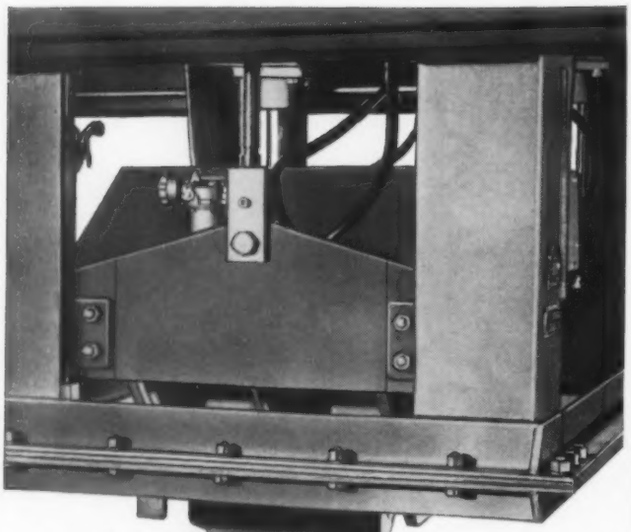
Selectoheat control takes tap sequence changing off the transformer top . . . brings the job down to earth for speed, ease *and safety, too.* Tap leads run direct to motor-operated tap changer in convenient work-level compartment. Main tank is opened only for periodic inspection. And because there's no need for under-oil terminal boards, transformer height is reduced — less headroom required.

Call your A-C man for details or write Allis-Chalmers, Power Equipment Division, Milwaukee 1, Wisconsin.

Selectoheat is an Allis-Chalmers trademark.

ALLIS-CHALMERS

A-1175-IS

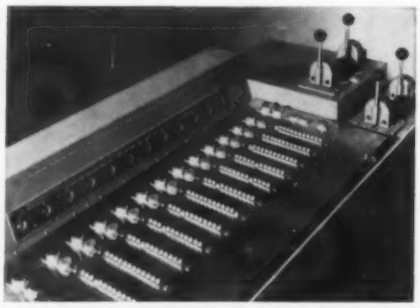


WORLD'S
MOST ADVANCED

Slab AND Bloom Marker

Characters are changed in the marking head and the stamping cycle is actuated from a remotely-positioned operator's console. Among refinements introduced in this latest GY-46 Series: raising and lowering of marking head can clear for 24" bloom . . . keystrips for automatic setup of characters . . . provision for use of printed tapes . . . automatic oiling system . . . provision for setting up by IBM or other punch card system.

On the operator's console a 12-position keystrip may be provided for each of the 12 wheels in the marking head. A press of a button moves any wheel to desired position.



Get comprehensive details in new 4-page Bulletin #613-D-Rev.

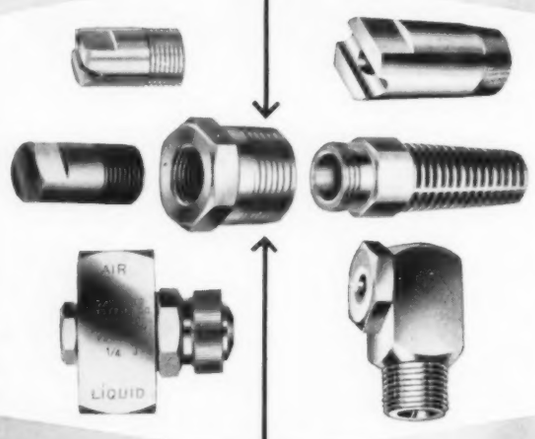
Mecco SAFETY Model 701-RCW
SLAB MARKER
A Product of the Marking Device Industry
M. E. CUNNINGHAM CO.
1041 CHATEAU STREET, PITTSBURGH 33, PA.

proved
SPRAY NOZZLE
design

TO IMPROVE SUCH SPRAYING OPERATIONS AS

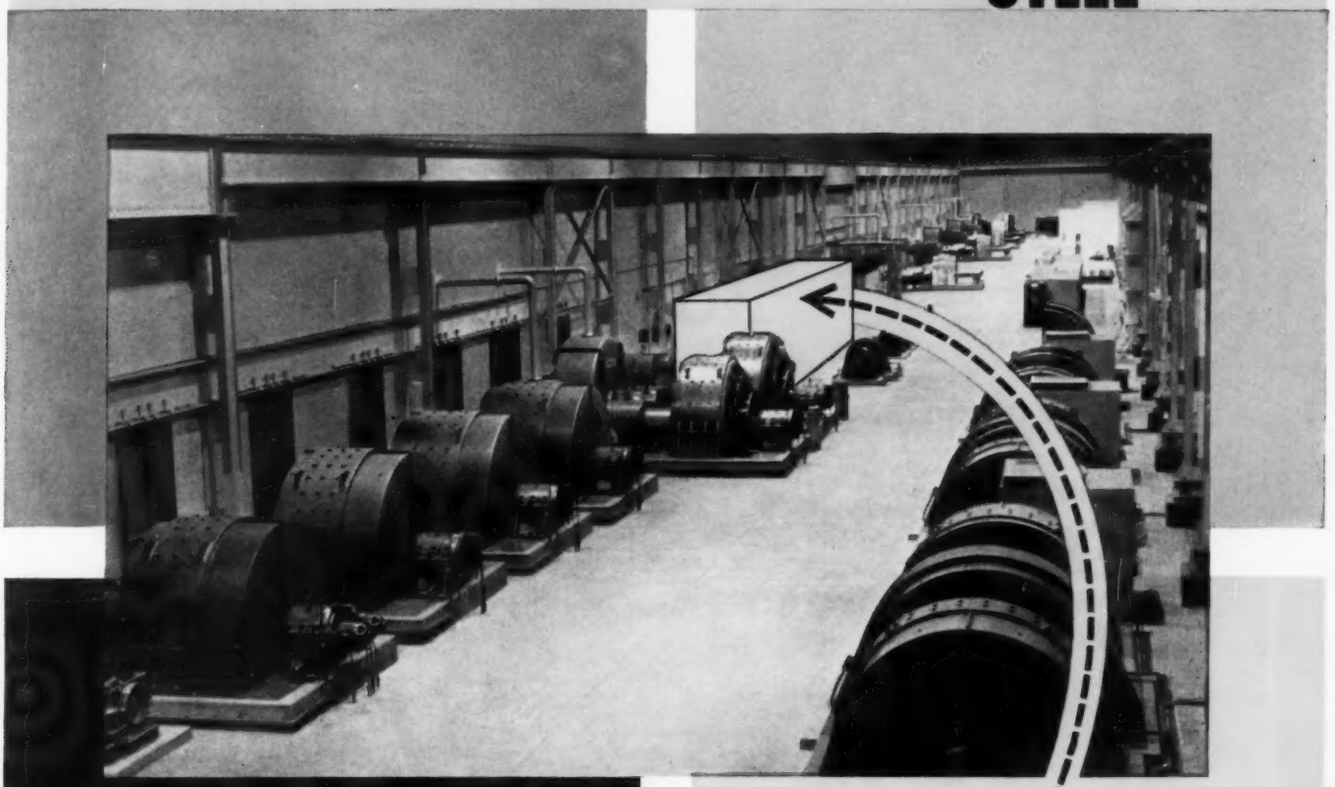
• DESCALING • HOT STRIP COOLING • ROLL COOLING • COOLING SLABS—INGOT MOLDS — OPEN HEARTH TUNNELS — PIGS • COKE CHEMICAL PROCESSING • LUBRICANT SPRAYING • AIR AND GAS WASHING

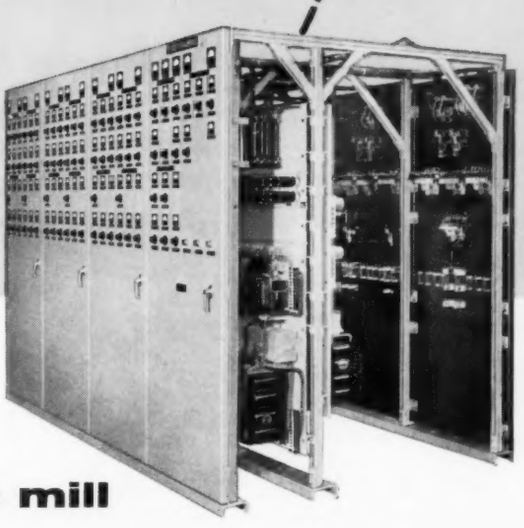
Whatever the application you will find Spraying Systems Spray Nozzles provide noticeable improvement in spraying operations . . . and often materially lower cost. Proved by performance. Supplied in a complete choice of types and capacities for selection of spray characteristics exactly as needed. Your inquiry is cordially invited.



SPRAYING SYSTEMS CO.
3262 Randolph Street • Bellwood, Illinois
For complete information write for Catalog 24 and special data sheet folder "Steel Mill Applications".

ALLIS-CHALMERS . . . in step with **STEEL**





NEW

Regulators modernize mill

Yield has been increased . . . scrap decreased as width and thickness of strip are held to closer tolerances.

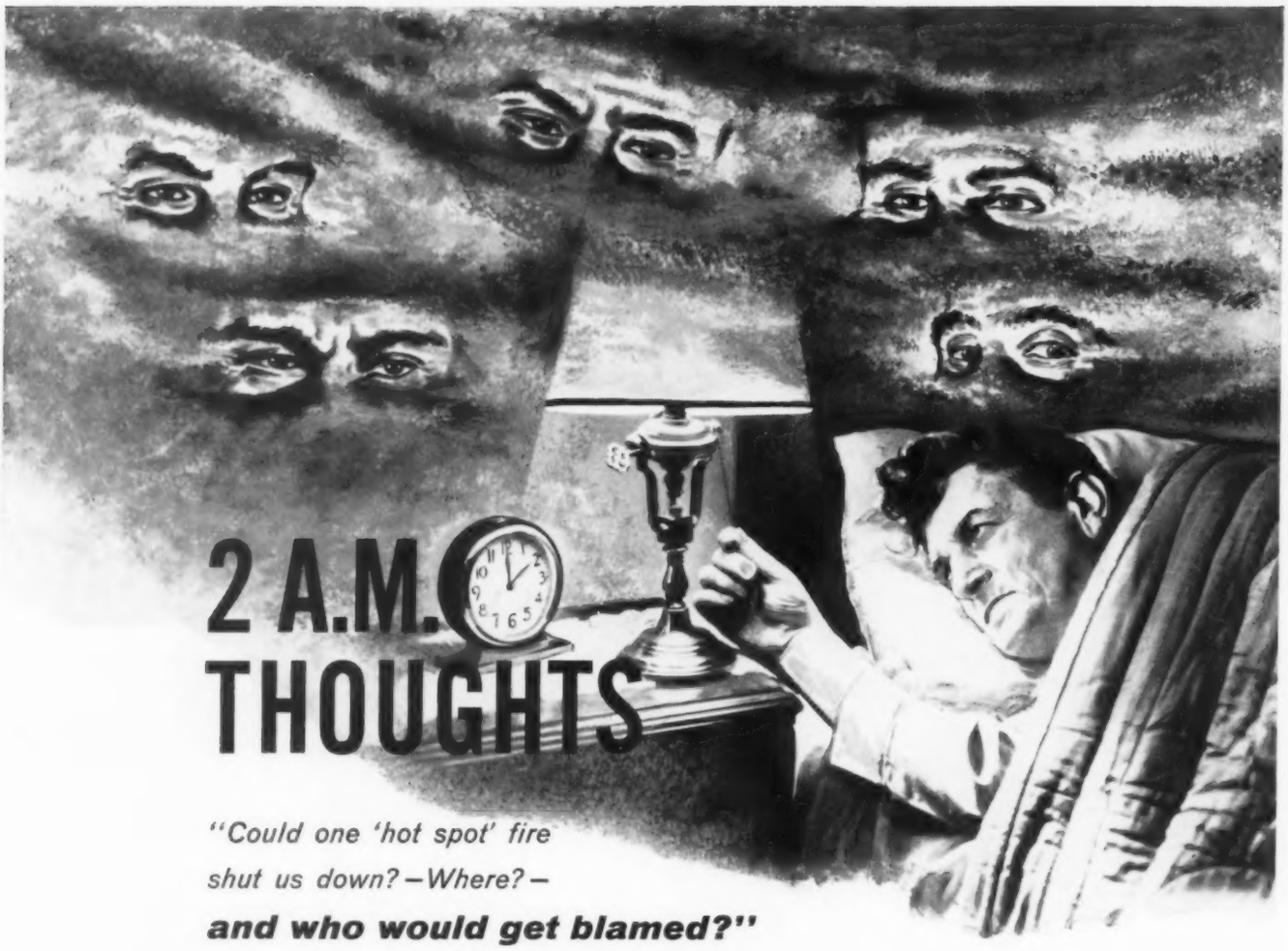
Nothing was changed except the control in this large eastern mill. The motor room of this 68-inch hot-strip mill looks practically the same as it did five years ago, but it's all new in operation.

New Allis-Chalmers stand speed regulators and bus voltage regulators featuring magnetic amplifiers make the difference. They were specifically engineered to provide a high gain, fast response system for consistent performance of the mill so that more high-quality product can be rolled.

Find out what modern control can do for your operations. Contact your nearby A-C office, or write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin.

ALLIS-CHALMERS

A-5964-1S



Not restful thoughts—but useful if you are responsible for fire protection — or likely to be faced with the results of one bad fire.

"Hot spot" fires happen every day—hit with sudden fury at efficient but hazardous operations. If you have a fire, the odds are that it will start in a "hot spot." Typical are quench and dip tanks, spray booths and tunnels, oil cellars, transformers and their vaults, generators —processing, storage and pumping of flammable liquids. You may have many others equally dangerous.

LET US HELP FIND AND EVALUATE YOUR "HOT SPOTS"

Write and we'll arrange a meeting with a Cardox Fire Protection Engineer.

CARDOX

CHEMETRON

DIVISION OF CHEMETRON CORPORATION
840 N. Michigan Avenue
Chicago 11, Illinois

DISTRICT OFFICES IN PRINCIPAL CITIES

For Maximum "Hot Spots"

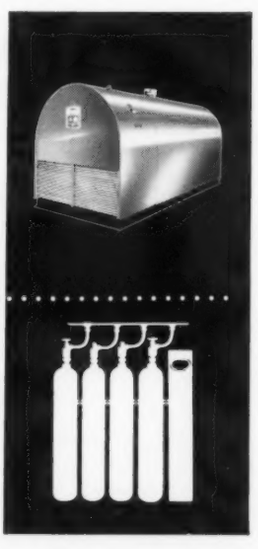
CARDOX® CARBON DIOXIDE SYSTEMS

Assure maximum protection

Performance-engineered to meet the specific conditions of each hazard according to maximum-safety standards established by Cardox over the last 20 years, these systems have proved themselves —*by actual records*—in thousands of installations. Fully automatic when required—no extinguishment damage *ever*. Your judgment in choosing a Cardox-Engineered System is backed by leading fire protection authorities.

LOW PRESSURE SYSTEMS

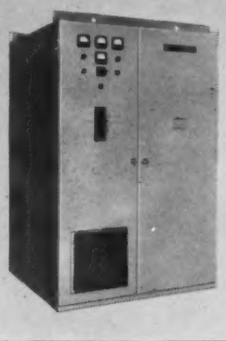
Highest form of engineered protection for critical special hazards. The systems that made carbon dioxide *No. 1 protection* for so many of industry's toughest hazards. Originated, pioneered and perfected by Cardox. Thousands of pounds-per-minute application of carbon dioxide if needed. Centralized storage of any quantity of carbon dioxide—lbs. to tons—any number of hazards, indoors or out.

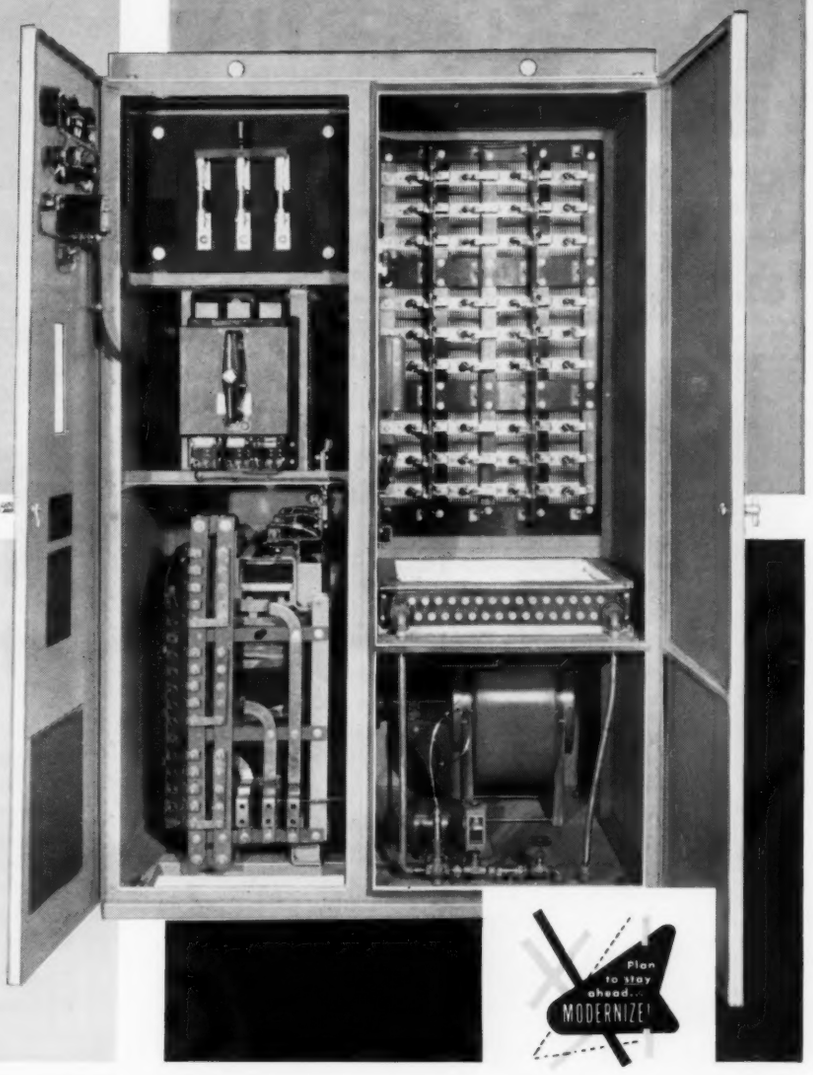


NEW HIGH PRESSURE SYSTEMS

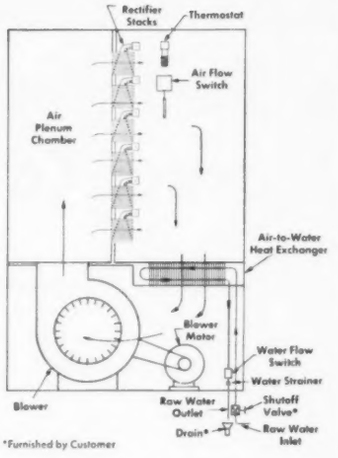
The first *performance-engineered* high pressure systems for smaller capacity needs or physical conditions where cylinder-type systems offer advantages. Exclusive constantly energized, continuously monitored control system. Total flooding and local application by any means of application. GET THE FACTS!

ALLIS-CHALMERS...in step with **STEEL**



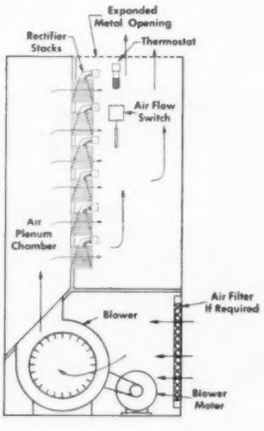


CHOICE OF COOLING SYSTEMS



*Furnished by Customer

A recirculating air system featuring an air-to-water heat exchange is employed where atmosphere is corrosive or dusty.



A simple air-cooling method is recommended for use in near normal atmospheres and where water is not available.

CORRECT APPLICATION

is the key to semi-conductor rectifier efficiency in the steel industry

Sure, you're looking for the high conversion efficiency, low maintenance and simplified operation associated with semi-conductor rectifiers. And you'll get all these advantages — and more — if the semi-conductor rectifier is a right-for-the-job installation.

Your local Allis-Chalmers man will be glad to tell you whether *or not* a semi-conductor rectifier is best for your specific steel industry operation. He can afford to be completely unbiased in his approach to your problem because Allis-Chalmers makes *all types* of power rectifiers. At his disposal, and yours, are vast research and engineering facilities. Behind his recommendation is the world of assurance found in the fact that Allis-Chalmers has been developing, building and applying rectifiers in the steel industry for almost 25 years.

For complete information, call your A-C representative or write Allis-Chalmers, Industrial Equipment Division, Milwaukee 1, Wisconsin. In Canada, write Canadian Allis-Chalmers Ltd., Box 37, Montreal, Quebec.

A-5950-1S **ALLIS-CHALMERS**

DeZURIK VALVES

give you more

at lower cost!

EASY OPERATION

DeZurik Valves open and close EASILY because the plug touches the valve body ONLY when the valve is closed. Pivoting the plug eccentrically means no binding, no scraping, no scoring.

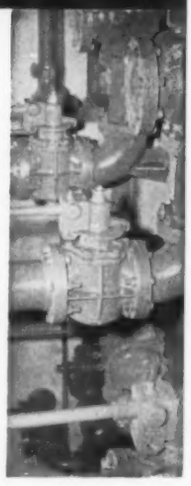
TIGHT SHUT-OFF

Dead-tight shut-off is guaranteed—every time—by the resilient facing on the plug of a DeZurik Valve. There's no chatter, no leaking, when you install DeZurik Valves.

WITH ECCENTRIC ACTION

NO MAINTENANCE

Because of their eccentric action and resilient-faced plugs, DeZurik Valves need no lubrication to provide easy operation and deliver tight shut-off. No guns or greases to stock, no lube schedule to maintain. And no stem leakage.



LONGER LIFE

DeZurik Valves last longer on tough services. Their resilient-faced plugs resist erosion on abrasive flows—and they can be furnished in a wide variety of trim for corrosive flows.

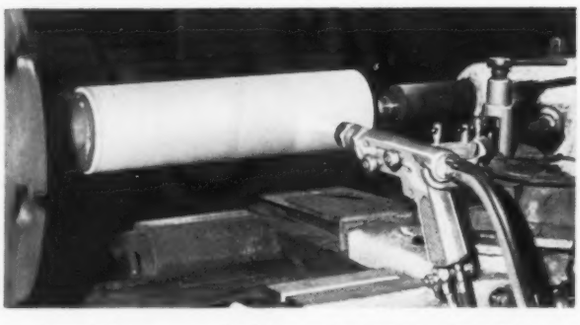
DeZurik Valves are available in sizes from ½" thru 20". See the DeZurik representative in your area or write for details.

DeZURIK CORPORATION
SARTELL, MINNESOTA

SPRAYWELD® Hard Surfacing Cuts Journal Costs

Table roller journal sleeve maintenance costs were cut from $21.06 to only $1.50 each per month through the use of the Colmonoy Spraywelder (reports the September 1957 issue of *Iron and Steel Engineer*). The Spraywelder, a universally accepted powder metal spraying unit, applies Colmonoy hard-surfacing alloys to provide low-cost protection against abrasion, impact, heat, and corrosion.

The Colmonoy Spraywelder sprays powdered Colmonoy alloys to form smooth, even overlays. The overlays are then fused to the part, forming an integral surface of wear-resistant alloy. Write now for complete information about this versatile maintenance tool.



Journal sleeves are made of low carbon seamless steel tubing, with an overlay of Colmonoy No. 6 hard-surfacing alloy, applied by the Spraywelder. The sleeve is rotated in a lathe, with the Spraywelder mounted in a tool-post holder.

HARD-SURFACING AND BRAZING ALLOYS

WALL COLMONOY CORPORATION
19345 John R Street • Detroit 3, Michigan

BIRMINGHAM · BUFFALO · CHICAGO · HOUSTON · LOS ANGELES
MORRISVILLE, PA. · NEW YORK · PITTSBURGH · MONTREAL · GREAT BRITAIN

Taylor IS TODAY'S BIG

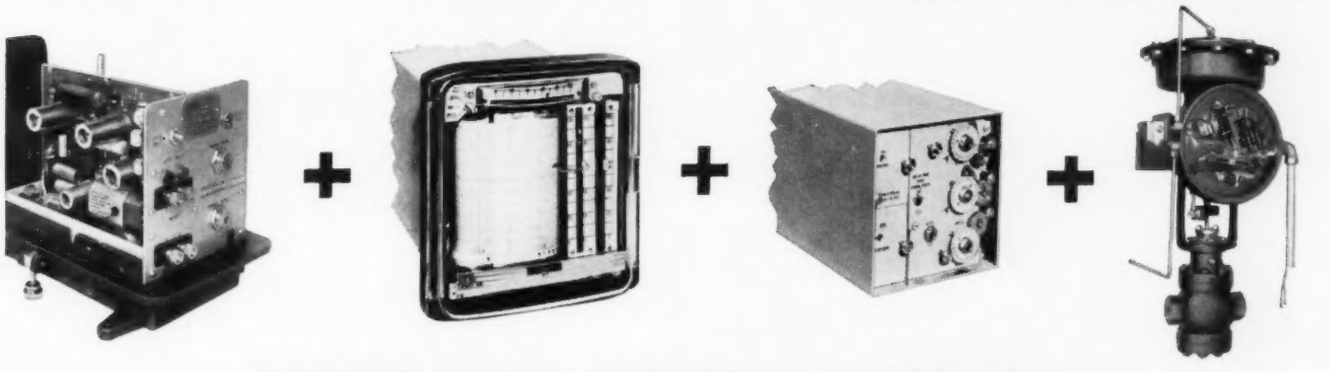
NAME IN ELECTRONIC PROCESS CONTROL

The name 'Taylor' has long been famous for pneumatic control. This reputation was recently enhanced by the introduction of the highly successful TRANSCOPE* pneumatic line.

Now, one year since their announcement, TRANSCOPE Electronic instruments have already established new standards of convenience and accuracy.

Paralleling all the outstanding features of the TRANSCOPE pneumatic line, these electronic instruments have proven their dependability in field service. They are "naturals" for the metals industry. Why not call in your Taylor Field Engineer to consult with you, or write for **Catalog 98335.** Taylor Instrument Companies, Rochester, N.Y., and Toronto, Ont.

TRANSMITTER **RECORDER** **CONTROLLER** **VALVE POSITIONER**



= ELECTRONIC PROCESS CONTROL

700T Potentiometer Transmitter is famous for high accuracy and dependability. Senses and converts Temperature (either thermocouple or resistance elements), Load, Speed, pH or other millivolt signals to an electrical and/or pneumatic output. Electronic balancing. No need for slide wires, batteries, cells or moving parts. Interchangeable plug-in service cans permit quick adaption for use with different primary elements.

701J AC or DC Recorder is all transistorized, unaffected by ±10% line voltage variation. Positive, precise pen positioning assured by extremely powerful servo-motor. Control settings can be made from front or rear of case. Plug-in Recorder slide can be removed without disturbing process control.
Other plug-in features include set point transmitter, automatic-to-manual switching unit and controller mechanism.

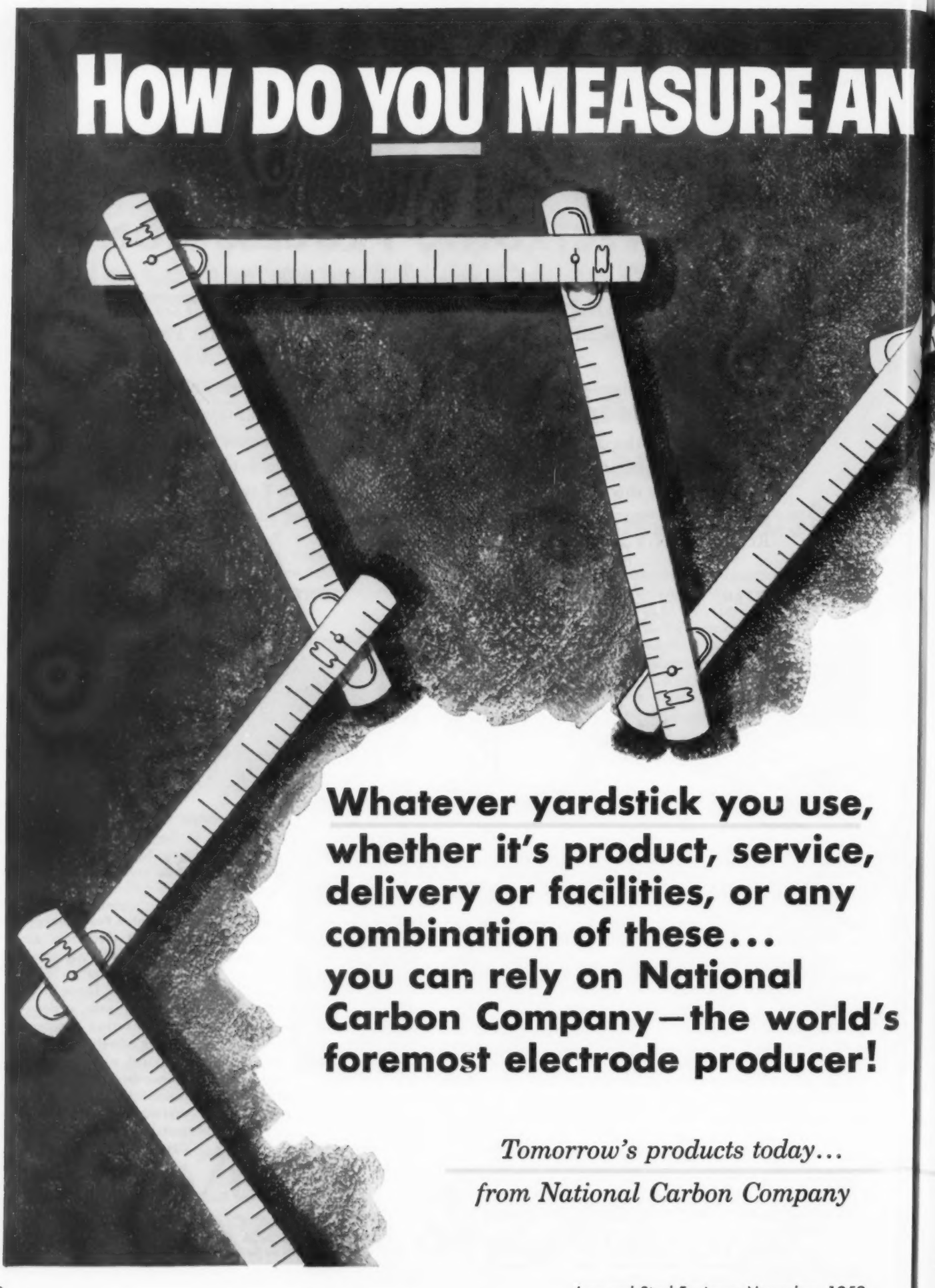
704R AC or DC Controller has all benefits of most advanced control circuits. Unique diode limiter circuit permits even two-response controllers to eliminate over-peaking on most applications. Effective at all times whether variable is approaching control point from above or below; on changes in set-point; following major process disturbances, or on start-up.
Unaffected by line voltage changes up to ±10%.

713R Valve Positioner couples advanced electronic control with smooth pneumatic action. Converts an electrical milliampere input from the controller into a pneumatic force, insuring positive positioning of valve actuator proportional to electrical input. Unmatched stability, due to a powerful, balanced armature that minimizes effects of shock and vibration. Designed for Class 1, Group D, Division 1 equipment.

*Reg. U.S. Pat. Off.

Taylor Instruments **MEAN ACCURACY FIRST**

HOW DO YOU MEASURE AN



Whatever yardstick you use, whether it's product, service, delivery or facilities, or any combination of these... you can rely on National Carbon Company—the world's foremost electrode producer!

Tomorrow's products today...

from National Carbon Company

ELECTRODE SUPPLIER ?

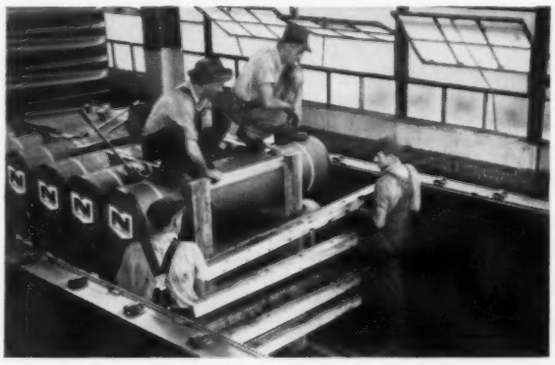
PRODUCT...

Years of experience combined with continuing extensive research and development provide product quality recognized to be the highest in the industry.

SERVICE...

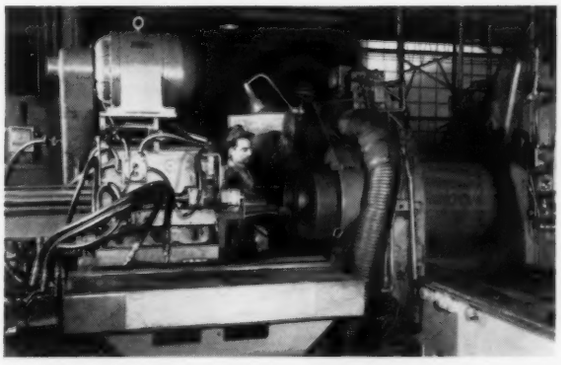
A group of highly qualified service engineers to offer assistance in attaining peak electrode operational efficiency, maximum power utilization, and improved joints.

DELIVERY...



Orders are shipped promptly by National Carbon Company. Damage-Free gondola car shipments—initiated by National Carbon Company—carry greater loads, simplify unloading and avoid demurrage. This saves you penalty fees and reduces transportation and handling costs.

FACILITIES...



At National Carbon's eight domestic plants, the combination of experienced personnel, especially designed production equipment, and stringent quality control assure a flow of quality products unmatched in the industry today.

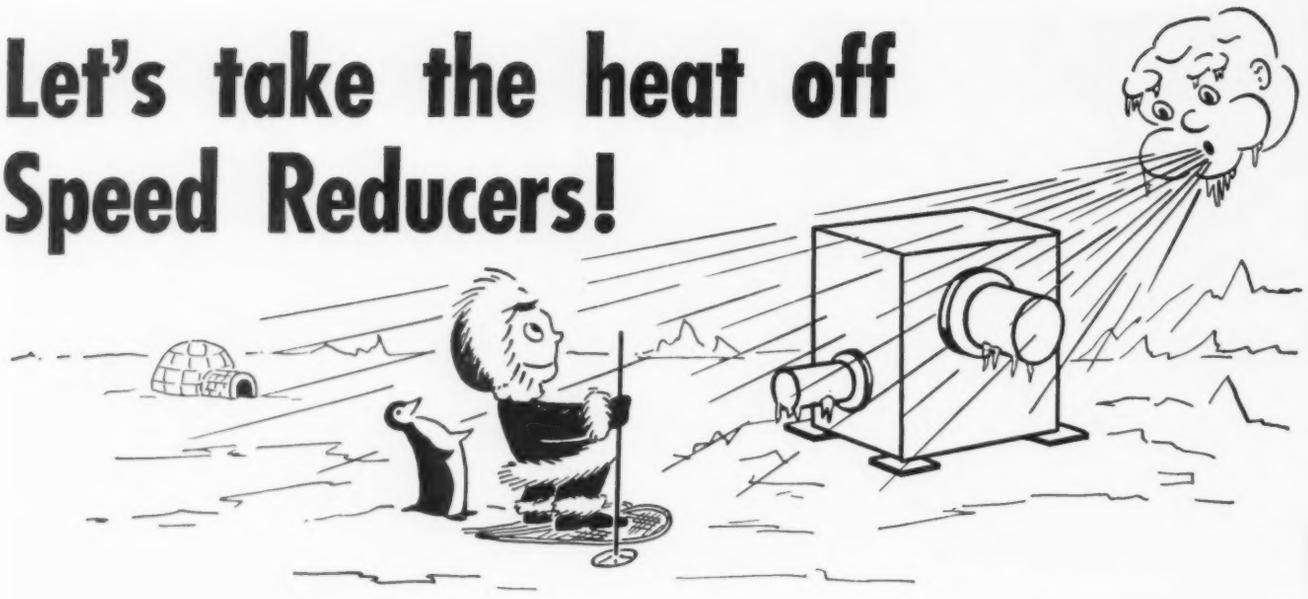
UNION CARBIDE

"National" and "Union Carbide" are registered trade-marks of Union Carbide Corporation

NATIONAL CARBON COMPANY • **Division of Union Carbide Corporation** • ***30 East 42nd Street, New York 17, N. Y.***

OFFICES: Birmingham, Chicago, Houston, Kansas City, Los Angeles, New York, Pittsburgh, San Francisco • **IN CANADA:** Union Carbide Canada Limited, Toronto

Let's take the heat off Speed Reducers!



A worm gear speed reducer is one of the toughest little customers in captivity. It reduces speeds day-in, day-out, with little complaint. While it works long and hard, it has limitations—set by ratio, center distance, RPM, mechanical and thermal HP ratings, etc. And, depending upon how precisely it was selected and fitted to the job requirements, it will do what it has to do.

But sometimes it's forced to play outside of its league. It must cope with job requirements that vary from here to there—normal 8 to 10 hour service without recurrent shock, the same length of service where there is some shock loading, continuous low-speed service and almost countless others. But the thing that really puts the pressure on reducers, the thing that's lurking in *every* set of job requirements—is h-e-a-t.

When you exceed the thermal capacity of a reducer for more than an hour or so, excessive temperature thins the lubricant resulting in wear; material, bearing and oil seal failures; etc. Of course, the proper lubricant will help but it can't cure the continuing problem of excessive heat.

So how can we lick this toughy? One way is to build the reducer housing oversize, big enough to radiate the heat away and keep temperatures down. But this type sticks out in aisles, louses up compact designs and barks shins. Then, we might try a smaller housing complete with fins on it to dissipate the heat. If this still doesn't work, another trick is to use a reducer with capacities and ratings a step above the ones we need. This is sending a man to do a boy's job. It's impractical, inefficient and costly. There *has* to be an easier, better, saner and cheaper way to do it. And there is!

In certain cases, where the size and type of reducer permits and where we can gain enough in thermal HP rating to keep heat generation in bounds, Cone-Drive Gears does it with fan-cooling.

What's that? Simple. Just add a fan to the worm shaft plus the necessary air shields, fan cover, etc., and presto!—heat is no longer a problem. The air shields direct the fan-pushed air over the fins on the lower portion of the reducer. The fins are shaped and spotted to guide the air stream where it is needed. Thermal HP ratings are boosted tremendously, as high as 147% above those of standard reducers in some cases! Those over-worked, over-heated reducers will now do the job you bought them to do.

Other advantages? They're here in abundance. The size of the reducer stays the same. All parts on a Cone-Drive fan-cooled reducer are 100% interchangeable with parts for standard reducers. Oil capacity is identical. Shields are quickly removed without disconnecting the reducer. (This is important where severe operating conditions make periodic cleaning necessary). The reducer can also be operated *without* fan-cooling just by taking off the fan and shields.

This simple addition to standard Cone-Drive HU speed reducers might be just your answer—might save you some money. Write for Cone-Drive's Bulletin CD-218. It will tell you all about the full line of Cone-Drive double-enveloping worm gear reducers as well as the fan-cooled kind. Cone-Drive Gears, Div. Michigan Tool Co., 7171 E. McNichols Rd., Detroit 12, Mich.

As more and more steel companies expand they specify SALEM Soaking Pits

When steel companies require new soaking pits to heat ingots for rolling, more and more they are specifying Salem. One steel company operating official recently said, "The previous installation heated more steel ingots ready for rolling with less fuel consumption, less maintenance cost and better temperature uniformity than any other type of pit in our plant, so we have again turned to Salem-Brosius." The recently completed pits shown above are good examples of Salem-Brosius' advanced design. They are of the 2-burner, single-end top-fired type, fitted with needle-type metallic recuperators and *capable of placing 200 tons of steel under cover per pit.*

Good performance reports are typical . . . not only concerning soaking pits, but all other Salem-Brosius heating and heat-treating furnaces. Salem-Brosius engineers are well known for their ability to design furnaces for maximum uniform output at minimum operating cost. If your plans call for replacing old furnaces or adding new ones, why not ask us to bid? There will be no obligation.

SALEM-BROSIUS, INC.

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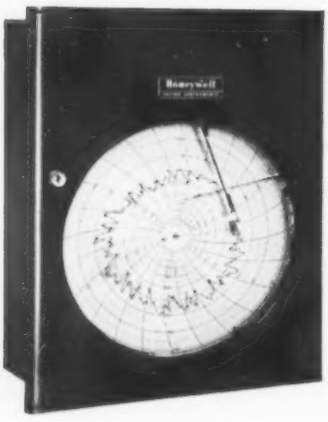
Salem Engineering Limited, Toronto, Ontario • Salem Engineering Co., Ltd., London & Milford, England • Salem-Brosius, S.A., Luxembourg • Salem-Brosius, S.A., Paris, France • Alloy Manufacturing Corp., Pittsburgh, Pennsylvania • R. H. Freitag Manufacturing Div., Akron, Ohio • General Ionics Corp., Pittsburgh, Pennsylvania.

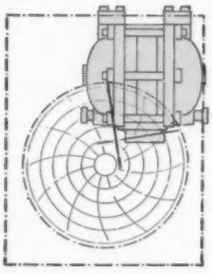
Honeywell Bellows Flow Meter

HERE ARE FOUR OF MANY WAYS YOU CAN USE THE BELLOWS FLOW METER



For direct measurement and control

the meter is integrally mounted on indicators, indicating controllers, recorders, or recording controllers.



With an indicator or recorder—Indicators can be supplied with or without pneumatic transmission. Recorders can be one, two or three-pen instruments, with the second and third pens actuated by thermometer and/or pressure elements.

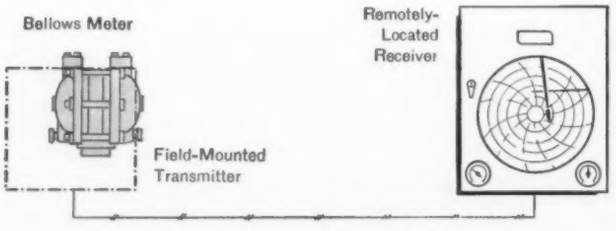
With indicating or recording controllers—All indicators and recorders can be supplied with any pneumatic control form from on-off to three-mode. Indicating controllers are also available with pneumatic transmission.

With a "blind" transmitter—the non-indicating differential pressure transmitter is used when indication is not required at the process and the variable is to be transmitted to remotely located instruments.

With an indicating transmitter—Scale is graduated in accordance with the flow or liquid level span of the transmitter. These transmitters are available with pneumatic control to remotely operate final control elements.

For remote measurement and control

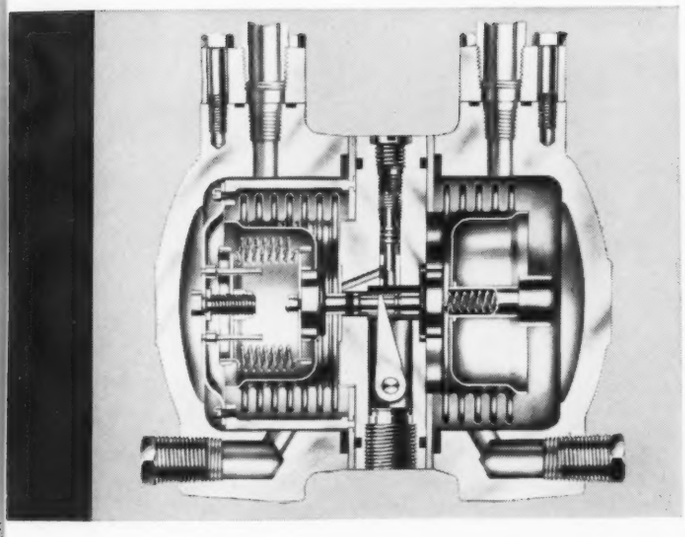
Field-mounted transmitters, either "blind" or indicating, can be used with remotely located indicators, recorders, and controllers.



and with Tel-O-Set miniature instruments and a variety of options!

has applications unlimited

Unequaled for accuracy, stability, versatility in flow and liquid level metering



Transfer of liquid between opposing high and low-pressure bellows converts differential pressure measurement into motion. A torque tube assembly carries the motion outside the meter body to an instrument. Therefore, changes in differential pressure change the instrument reading.

Here's the most advanced meter body available today, with advantages never before found in flow and liquid level meters. Combine the new Honeywell Bellows Flow Meter with the instruments shown on the facing page for truly superior service in metering steam, water, gas, oil and other fluids.

Some of its outstanding features:

Sensitive and accurate—Sensitive to within 0.05% of full scale . . . calibrated accuracy ± 0.5% of full scale.

Leakproof—Between liquid fill and process fluid.

Automatically stabilized—Changes in meter body temperature or static pressure have no effect on output shaft position. Meter operates efficiently in ambient temperatures of minus 40°F to plus 250°F.

Unmatched convenience features—Including fast range changing in the field . . . connections for both horizontal and vertical piping . . . quick calibration and adjustment . . . easy cleaning and servicing.

High corrosion resistance—Seamless, stainless steel formed bellows give long, trouble-free service with virtually all process fluids.

Fast, effective damping adjustment—New type pulsation check with rectangular orifice permits essentially linear damping adjustment . . . and adjustment from outside the meter body during operation.

Models are available in many ranges, for both flow and liquid level measurement and control. Get details on *all* the features of the new Honeywell Bellows Flow Meter by calling your nearby Honeywell field engineer today . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa.

● **REFERENCE DATA: Catalog C22-1**

Honeywell

H HONEYWELL *First in Control*

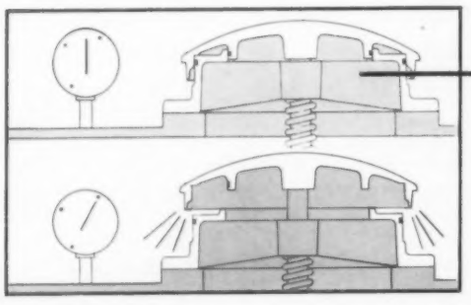
FURNACE TRANSFORMER NEWS:

The space-saving rectangular tank now standard for all Pennsylvania Furnace Transformers saves as much as 25% in overall floor space. New vaults can be smaller, less costly. Existing vaults will accommodate replacement transformers of greater capacity.

Two recently developed *time-saving* features are provided with the new space-saving rectangular tank. They are:

1 FULLY AUTOMATIC PRESSURE-RELIEF DEVICE

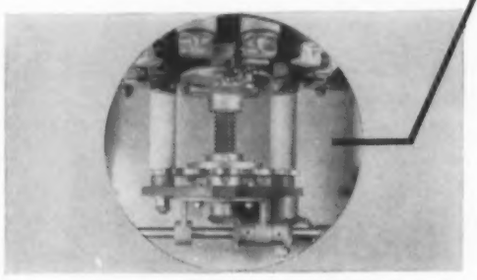
This new mechanical pressure-relief device relieves internal pressure at a predetermined setting by temporarily breaking a gasket seal around the valve cover . . . then completely and automatically reseals itself so that the device is fully effective. There are no parts to replace . . . no resetting is needed . . . *no breathing takes place* after the release of pressure. This prevents the entrance of moisture and other contaminating elements.



Top view shows pressure-relief device in sealed position. Bottom view shows how cover is raised to permit release of pressure, after which device automatically reseals itself.

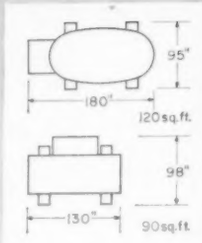
2 EASY-TO-INSPECT TAP CHANGER

Pennsylvania's motor-driven tap changer is housed in separate compartments mounted on the transformer tank. This reduces down-time by greatly facilitating periodic inspection and maintenance. The mechanism includes a provision for emergency hand operation.



View through handhole in tap-changer compartment demonstrates ease-of-inspection feature.

Pennsylvania introduces

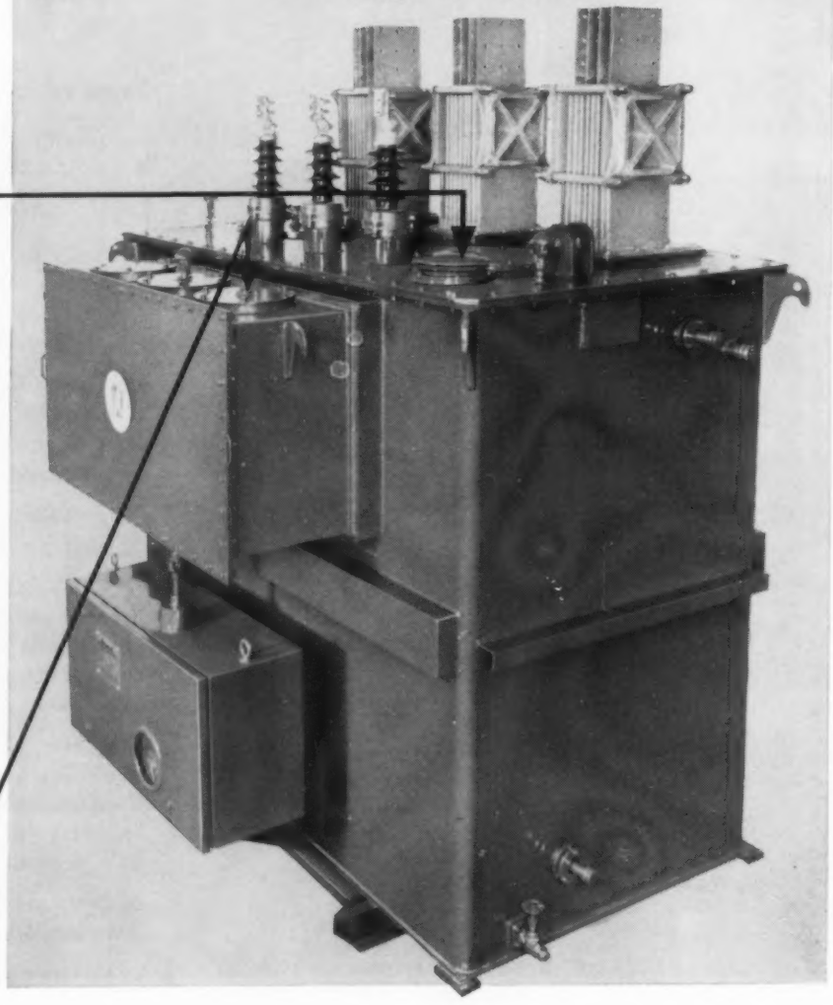


25% less floor space

Required for Typical 7500-Kva Transformer

SPACE-SAVING RECTANGULAR TANK...

equipped with 2 outstanding time-saving features



Pennsylvania has designed and built virtually every size and type of furnace transformer now in use: from 250 through 25,000 kva, and from 3175 through 82,000 amperes. To put this furnace transformer experience to work for you, contact Pennsylvania Transformer Division, McGraw-Edison Company, Canonsburg, Pa.

McGRAW EDISON

PENNSYLVANIA FURNACE TRANSFORMERS

Maintenance Of Mill Oil Bearings

Maintenance practices for optimum mill bearing performance are reviewed and described in detail

by C. A. Bailey,
Lubrication Engineer,
National Tube Div.,
United States Steel Corp.,
Pittsburgh, Pa.

and A. C. Cooper,
Superintendent
of Roll and Tool Shops,
Lorain Works,
National Tube Div.,
United States Steel Corp.,
Lorain, Ohio

THIS class of bearing was developed in this country in the late 1920's and early 1930's, primarily as a part of the broader development in mill machinery which included revolutionary changes in the rolling of all flat steel products, as a result of the success of the 4-high backup mill. There are two types of oil film bearings, the cylindrical, or straight neck, in which the journal is an integral part of the roll neck, and the tapered neck, in which the sleeve is an integral part of the bearing.

Though the oil film bearing found a useful application on certain types of 2-high mills, it became apparent that its greatest field of usefulness lay in its application to the backup rolls of the typical 4-high mill. This service presented certain problems not present in other oil-film bearings. The general hydrodynamic principles, governing the support of a moving surface or a rotating cylindrical journal on an oil film, were fairly well understood. However, the unit loads that must be carried, as a matter of course on this type of bearing in mill service, go far beyond what are encountered in most other applications. Furthermore, the bearings must perform under other exceedingly adverse conditions.

In hot mills, some specific adverse conditions are: proximity to the high temperatures of the metal being rolled; the presence of roll cooling water, often under fairly high pressure; and the hazard of abrasive mill scale, sometimes driven against or toward the bearing closures by high pressure hydraulic descaling jets.

An adverse condition encountered in cold mills is the presence of water, or other contaminating liquids, used

as coolants or lubricants in the rolling process. In some cases, extremely high rolling speeds are encountered, considering the size of the bearings and the loads carried. In nearly all cold mills, the bearings must operate at comparatively low threading speeds or start from rest repeatedly, sometimes under full load.

Such conditions are far from ideal. They impose exceedingly difficult conditions upon bearing design, particularly with reference to seals and lubrication. The exclusion of water, scale and grit, and the retention of the oil without serious leakage under mill conditions, become problems, not only for the bearing designer, but for the maintenance man. When the designer has done his best, it is the duty of maintenance to see that the safeguards built into the bearing by the manufacturer are retained throughout the life of the bearing.

MILL MAINTENANCE AND ROLL ALINEMENT

Before entering upon a detailed discussion of bearing maintenance, it may be well to mention certain factors that apply to all mill bearings, regardless of type. To avoid excessive axial thrust or end play, rolls should be held in close parallel alinement. Excessive end play may result in rapid wear of seal rings and rubbing of adjacent rotating parts that should run with axial clearance.

To insure satisfactory roll alinement, periodic checks should be made along the following lines. (A record of these checks should be kept and corrective measures should be taken when wear exceeds reasonable tolerances.)

1. Mill housing windows should be plumb, with side faces of windows at right angles to the centerline of travel through the mill. Checks should be made at the bottom, middle and top of the windows. New liners should be installed when the windows become badly worn.

2. With only the bottom backup roll in the mill, the top of the roll should be level. The liners and pressure blocks under the bottom bearing boxes should be checked for wear.

3. The width of all work roll and backup roll bearing boxes should be measured for wear at several points.

4. Bolts that are used to assemble split bearing boxes should be sledged up tight and kept in this condition.

5. Corrective measures should be taken, if wear becomes excessive on pads of bearing boxes, thrust bearing brackets and clamps. This is very important. With each roll change the fit of the clamps should be checked and clamp bolts tightened.

6. If excessive thrust and end play at clamps, due to wear, is not corrected, the following may result:

(*a*) Excessive lateral motion of the rolls when steel enters the stand.

(*b*) External wear on retainer rings, bolt heads, and other parts of the backup roll or bearing that should have axial running clearance.

(*c*) Greater thrust bearing or thrust bearing bracket maintenance.

(*d*) Bearing failures, due to the heat developed by parts, that should have axial clearance, rubbing together.

(*e*) Greater oil consumption.

MESTA OIL BEARINGS

The Mesta radial oil-film bearing was developed and built during the early 1930's to be applied principally to

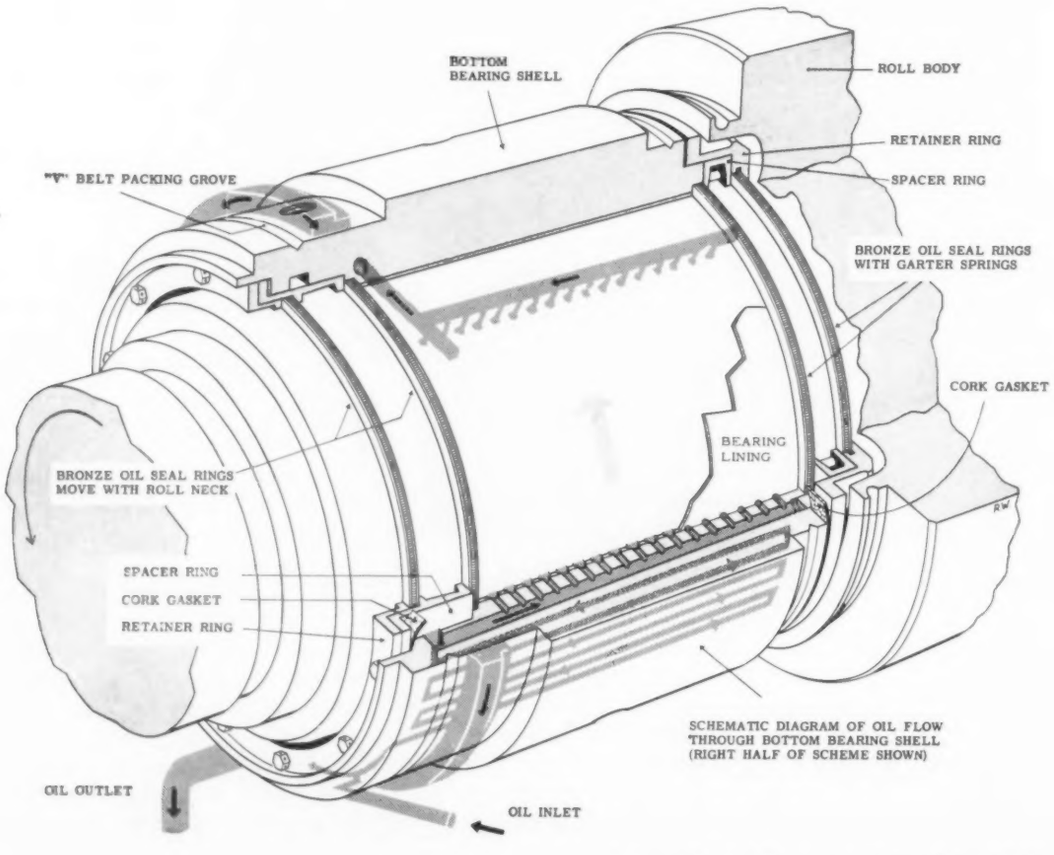


Figure 1 — The radial type, oil-film bearing is provided with an oil circulating system.

the roll necks of backup rolls on 4-high hot and cold rolling mills.

The bearings were developed in view of the high rolling loads and speeds to which roll neck bearings were subjected, the space limitations between the roll neck and the mill housings, the adverse water, dirt and scale conditions around many rolling mills, the low bearing friction requirements, and the gage accuracy required of the product being rolled. Other considerations were the need for a sturdily built bearing which could be readily inserted in or taken out of the mill housings, or put on or off necks for maintaining rolls and bearings. Some provision for taking the axial thrust imposed on the bearings by the rolls, during the rolling operation, was also an important requirement.

The Mesta oil-film bearings have met these requirements and in general have given long life and trouble-free service, particularly where well planned mill and bearing maintenance was periodically carried out. The vast majority of bearing shells and other bearing parts which have been applied are still in regular service.

General description—In this section, the discussion will relate primarily to the radial oil-film bearing used on straight neck type rolls.

This type oil bearing, Figure 1, consists of a bearing shell with a babbitt or other bearing lining. The oil is fed to the bearing under pressure through a series of coils in the shell discharging the lubricant into the bearing area through a series of longitudinal holes in the bearing lining. To provide an oil circulating system it is necessary for the lubricant to return to the storage tank by means of a definite channel. To accomplish this it is necessary to have a series of oil rings, return flow spacer rings, retainer rings, and cork gaskets assembled on each end of the bearing shell. The most important element in this assembly to provide oil circulation on a plain journal bearing, with minimum lubricant loss and contamination, is the oil seal ring itself. There are two of these seal rings on each end of the bearing shell, or a total of four rings on each bearing.

It is important to prevent loss of oil from the bearing and it is equally important to seal the bearing against entrance of water, mill scale and grit. The escape of the oil from the bearing during operation is prevented by the dual seals consisting of two closely fitted rings at the end of the bearing separated by the return flow spacers. These spacers are recessed to provide annular passages around the roll neck between the sealing rings. Any oil which may succeed in leaking past the inner ring drains into the annular passage. They are connected at the bottom to a longitudinal passage and thence past normally open check valves into the oil drain lines.

The outer sealing rings guard against the entrance of foreign matters from the outside and may be supplemented at the bearing end next to the roll body by labyrinth water seals, additional external seals, and water deflectors.

The oil seal ring is cut at one point to allow the garter spring, which is located in the groove of the seal ring, to hold the ring firmly on the roll neck. With a close fit between the inside diameter of the oil seal ring and the roll neck end and when held firmly by the garter spring, the oil seal ring turns with the roll. With the seal rings in this position they serve as collars on the roll journal

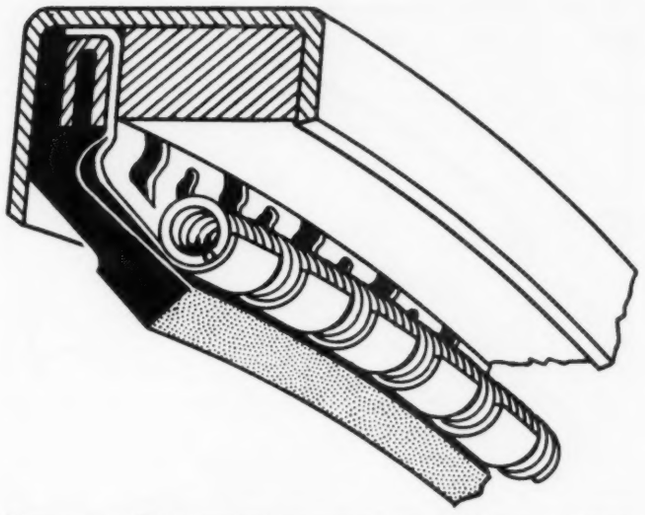


Figure 2 — This typical composition seal has a finger spring and a garter spring.

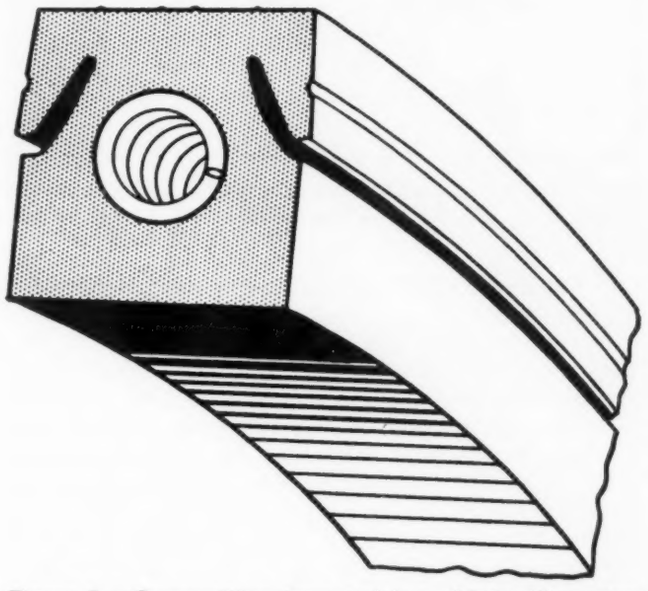


Figure 3 — Composition type seal is molded with garter spring inside.

rotating in the annular grooves between the spacer rings. Any contact or wear would take place between the sides of the oil seal ring and the spacer ring.

A feature of this bearing is the provision for oil circulation, exclusive of the oil forming the load carrying film and circulating through the load zone as it follows the journal in the direction of rotation. Oil is admitted to the bearing at the outer end, near the bottom, under pressure, and travels upward on both sides through passages, to the bottom edge of the side clearance spaces; here it is admitted to the clearance space on each side, through a series of small holes and directed radially inward, toward the journal surface. The oil then passes upward in a thin sheet, through the clearance space on each side, and leaves the bearing in a radially outward direction, through a similar series of exit holes. Further upward travel, through drilled passages, brings the oil to exit check valves at the top of the bearing. These valves are held open by pins, when the bearing is assembled in the bearing box, but close automatically to retain the oil, when the bearing box is removed. A spring loaded inlet valve prevents loss of oil

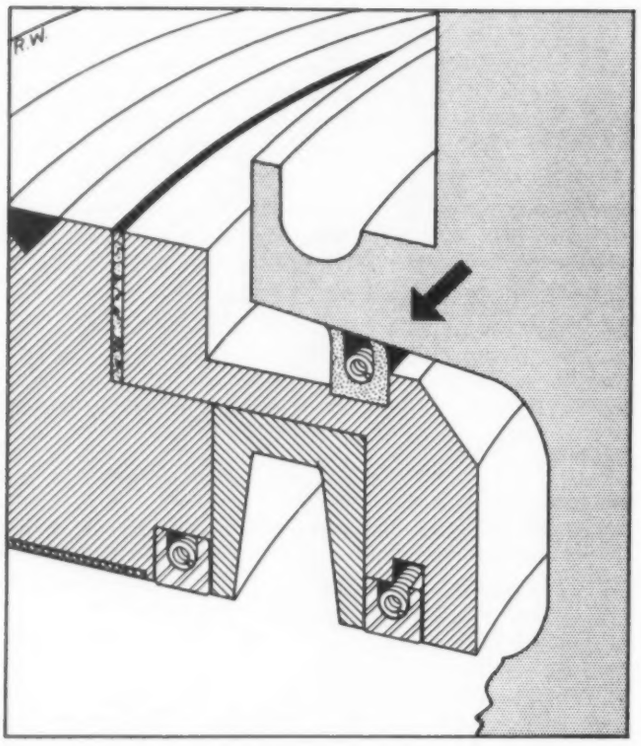


Figure 4 — A characteristic of this typical external seal is excellent maintenance performance.

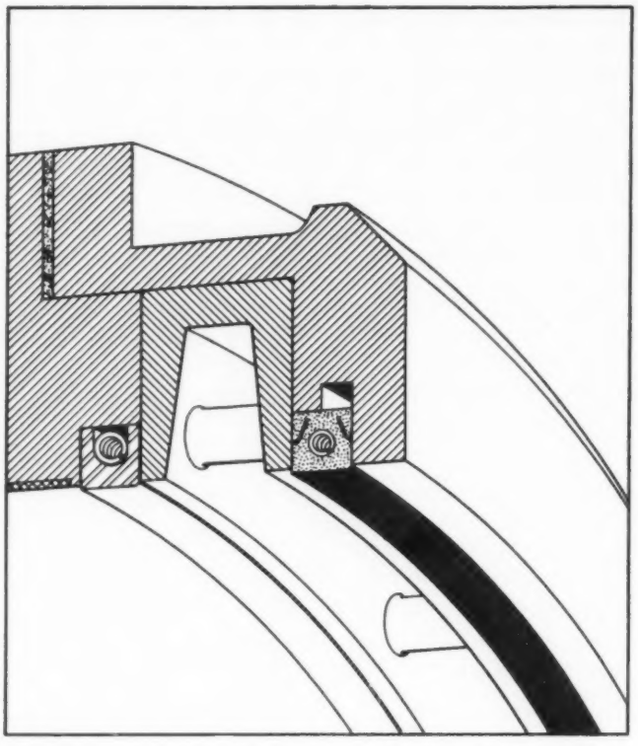


Figure 5 — Here a bronze seal and a composition seal are used in combination.

on the inlet side, when the inlet lines are disconnected for roll change.

This construction provides a cooling effect for a considerable volume of circulating oil, independent of the smaller volume that passes through the load zone. Whether the bearing is used as a bottom bearing with downward radial load, or as a top bearing with upward radial load, the extra oil circulation is from the bottom of the bearing to the top; this insures the entire bearing of being left full of oil, in case of a temporary failure in the circulating system. Suitable oil seals are provided, as will be described in further detail, to retain the oil and to exclude dirt, water, mill scale and grit.

Composition seals—Some operators replace the bronze seal rings with composition seals, often called soft seals. These closures are fabricated from nonmetallic materials such as neoprene, asbestos, plastics, leathers, etc. Considerable progress has been made in the development of materials and in improvement of design in this type of seal. See Figures 2, 3, 4, 5 and 6, illustrations of various types of composition seals.

However, statistical data collected by the authors reveal that about 12 per cent of the bearings in the mill stands covered by the investigation, had been converted wholly, or in part, to composition seal bearings. The statistics also show that the lowest oil consumption is obtained with the original bronze seals supplied by the bearing manufacturers, provided that there is strict adherence to the maintenance techniques and practices recommended in this paper. The bearing manufacturers do not advocate the use of composition seals in these bearings, but do not condemn them.

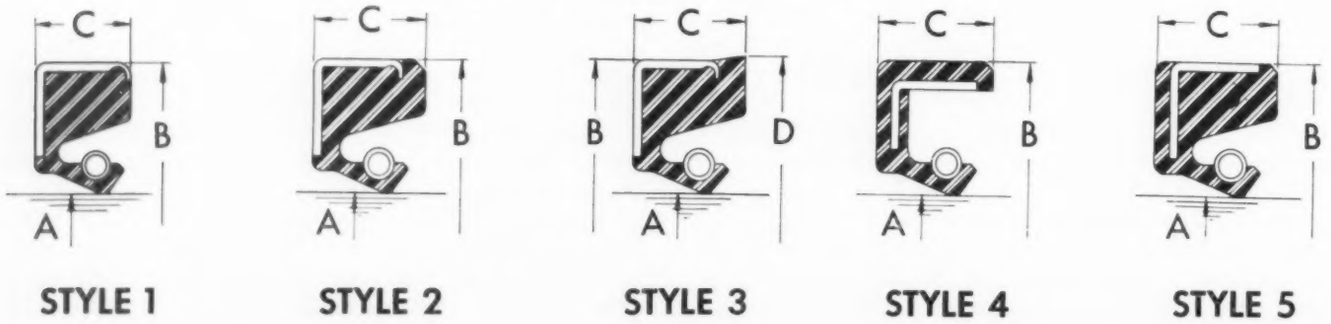
Advantages and disadvantages of composition seals are:

1. A lower initial cost, a lower installation cost and the requirement of less precision in assembly and adjustment for clearance.

2. The grooves supplied on roll necks of the original design damage the seal lip during installation. Therefore the seals must be used on roll necks without grooves.

3. Failure is complete when it occurs, giving little or no sealing protection between a somewhat sudden failure and replacement. This is in contrast to the performance of a bronze seal, which wears gradually with increasing leakage, but does not fail suddenly; this allows many hours of operation at reduced efficiency until a

Figure 6 — Various styles of composition seals.



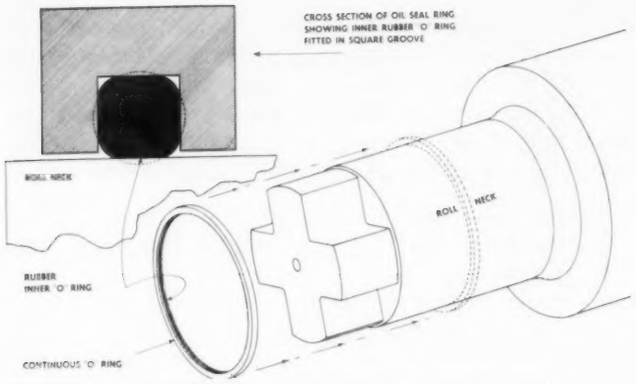

CROSS SECTION OF OIL SEAL RING SHOWING INNER RUBBER 'O' RING FITTED IN SQUARE GROOVE
ROLL NECK
ROLL NECK
RUBBER INNER 'O' RING
CONTINUOUS 'O' RING

Figure 7 — Oftentimes an O-ring inner seal is used.

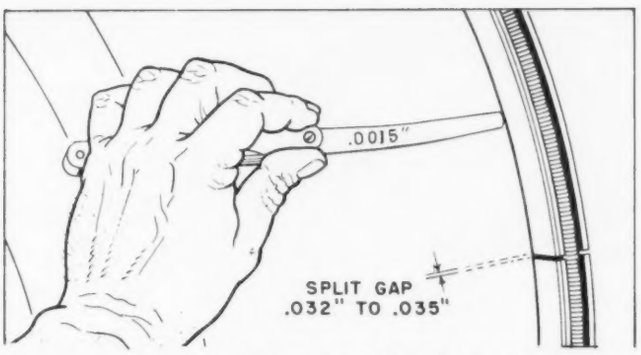


Figure 8 — The oil seal ring should be checked on the roll neck. Feeler gage of 0.0015 in. should not pass between the journal and inside diameter of the ring at any point of its circumference.

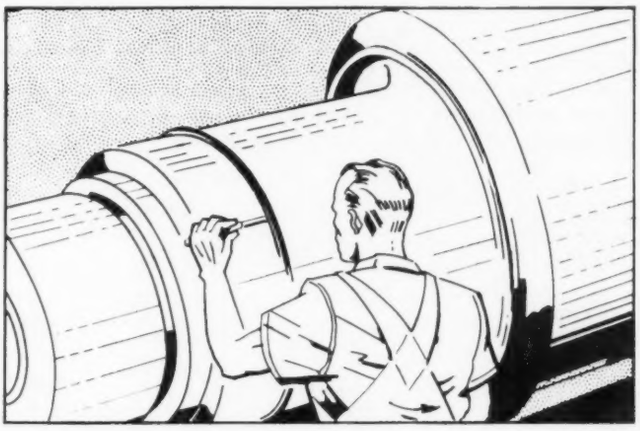


Figure 9 — The split gap should have a clearance of 0.032 or 0.035 in. to assure that the garter spring is always holding the seal ring firmly on the roll neck. There should be no slippage or wear taking place between the inside diameter of the oil seal ring and the journal.

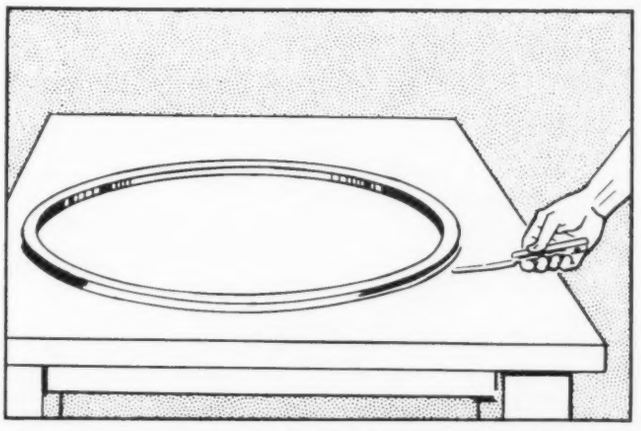


Figure 10 — The oil seal ring should be inspected on a machined flat plate to assure that the ring does not deviate from the surface plane by more than 0.0015 in. This is checked by a feeler gage not having sufficient space between the ring and the plate on any point of its circumference.

roll change can be made. These features may favor the use of a combination of bronze seals and composition seals in the same bearing.

4. A three-month maintenance and inspection period has been established, in comparison to a 12 to 15-month inspection period for bronze type seals.

5. Composition seals have given excellent performance as external or additional seals installed on the outside diameter of the bearing. These seals have a double lip in contact with the recessed end of the roll barrel which deflects the rolling solution, mill water, and scale and reduces the burden on the internal bearing seals.

O-ring seal—This method, Figure 7, makes use of solid bronze sealing rings which are of different design than the present split rings. The original standard seal was a solid ring which was improved by the addition of a garter spring and splitting the ring to hold it tightly on the roll neck. The O-ring method uses a solid bronze ring similar to the original design with the exception that it does not have a garter spring or a groove machined into the OD. The solid ring has a square $\frac{7}{16}$-in. groove machined into the ID.

The ring is assembled on the neck with 0.010 to 0.012-in. clearance with an O-ring pressed into the groove before assembly. The O-ring has a nominal diam of $\frac{15}{32}$ in. so that it has a $\frac{1}{32}$-in. squeeze. The presence of the O-ring causes the solid bronze sealing ring to rotate with the neck just as the garter spring did in the previous design.

The pressure of the seal from within the bearing holds the sealing ring tightly against the spacing ring so that wear takes place on the spacer ring side of the sealing ring only. The ring is allowed to wear as much as $\frac{1}{16}$-in. before it is removed and reversed for an equal amount of wear on the other side, then the ring is discarded. This type of seal is used only as the inner seal ring. The outer seal ring is either composition or the conventional design.

Diametrical clearances—The diametrical clearance of new bearings ranges from 0.020-in. for smaller bearings, to 0.030-in. for larger bearings. When the diametrical clearance reaches, through normal usage and wear, 0.050 to 0.060-in., the bearings should be reconditioned by relining. If bearings are allowed to reach larger diametrical clearance, they will be susceptive to excessive leakage. These clearances do not apply in those areas where relief has been provided for oil flow.

Ball checks—Each bearing is equipped with ball checks in both the inlet and outlet of the bearing shell. The inlet check is normally spring-closed and opens under sufficient oil pressure. Its function is to retain oil in the bearing during periods when oil pressure fails and thus leaves the bearing with retained oil for lubrication purposes. Its other function is to exclude foreign matter when the bearing is not in normal use.

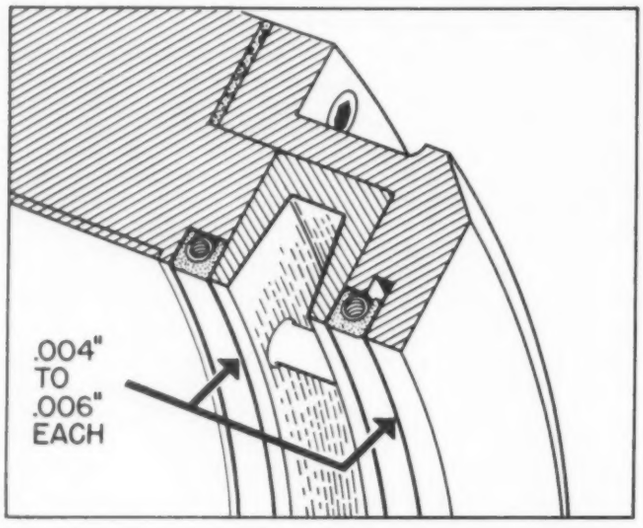


Figure 11 — When the oil seal ring is assembled, the side clearance between the ring and the spacers should be between 0.004 and 0.006 in. on all split rings.

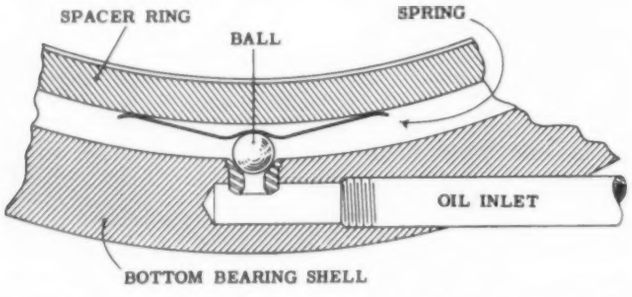


Figure 12 — Cross section of the spring-loaded ball check valve in the inlet of the bearing oil circulating system.

Adjustment of the spring-loaded check valve on the inlet should be checked as follows:

1. With the ball lying in its seat, the top of the ball should project $^{11}/_{64}$-in. above the bottom of the retaining ring groove.

2. The brass spring should be of a composition as furnished by the bearing manufacturers and should have dimensions as indicated in Figure 13.

3. When placed over the ball, with ball in its seat, both ends of the spring should project $^{1}/_{8}$-in. above the bottom of the retaining ring groove.

Bearing shop practice—The bearing change carriage, Figure 14, is a mechanical device for placing bearings on roll necks or removing same without the use of a crane. This device consists of a bed plate placed upon a foundation. The backup roll is positioned in the center of the device. Four-wheel trucks operating from each end of the bed plate on tracks carry the bearings to and from each end of the backup roll. The proper elevation for alinement with the roll neck is obtained by elevating screws on the carriage trucks. Care should be exercised in the assembly that the oil seal rings are not damaged or bumped in any manner. It is desirable that the necks be coated with extreme pressure fluid lubricant prior to the assembly.

Usually, bearing shells are removed from the split chucks for thorough inspection of the bearing surface, retainers, and seal rings.

Absolute cleanliness of all bearings is essential to prevent metallic chips or other materials from scoring the roll neck and the bearing surface. Hidden passageways and pockets must be thoroughly cleaned; this can only be done by complete bearing disassembly.

It is recommended that a separate area be used to inspect and clean oil bearings. The following materials, tools and aids should be available in this area:

1. A compressed air supply with $^{1}/_{4}$-in. blow pipe.
2. Nonmetallic spoked brushes for removing oil from passageways.
3. Steel rods with rag coverings for cleaning.
4. Cleaning solvent.
5. Portable lights and maintenance racks with rollers for positioning the bearings at a working height.
6. Complement of scrapers and files.

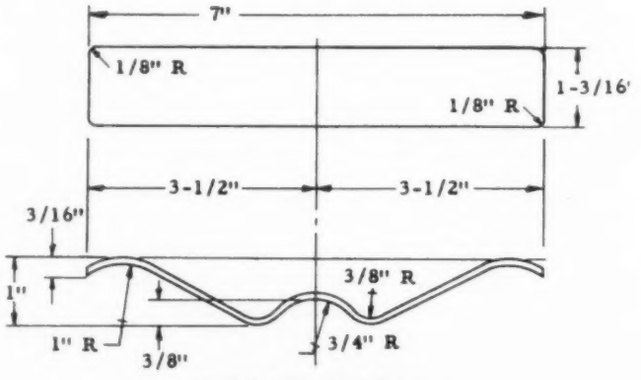
Should a bearing surface show signs of wiping or other defects, the wiped portion should be cleared with a flat scraper. Small areas of wiping, hard black spots or uneven surfaces are dressed up with hand scrapers. Final spotting of the bearing surface can be done, using bluing on the roll necks, followed by the slight rotation of the bearing on the roll neck, and scraping the bearing surface at points indicated by blue high spots. This process is repeated until small low spots occur at the rate of one per square inch or less.

Any particular bearing, when fitted with oil seals on a roll, should be used consistently on the same roll neck and not assembled interchangeably on other rolls.

Assembly of the bearing, after thorough cleaning with an approved cleaning solvent and an air jet, should proceed as recommended under "Spacers, Retainer Rings, Gaskets, and Seal Rings." Cork gaskets should be assembled dry. All steel parts should be assembled with a light coating of mineral oil to retard rusting. Pipe fittings, threads, and the split between half chucks should be coated with white lead.

The frequency of bearing strip downs will vary widely between plants and between mills. On hot strip mills, a strip down every four months seems reasonable, in view of scale and water. Local conditions vary within a range of 3 to 12 months on same mills. On cold mills the strip down should be about every four or six months, with a range of 3 to 12 months or more. Strip downs should, of course, be more frequent than indicated, in case of trouble or anticipated trouble, or in case mill alinement conditions are not desirable. Ample working

Figure 13 — Dimensions for oil inlet ball check valve spring.



BRASS SPRING
.022 THICK

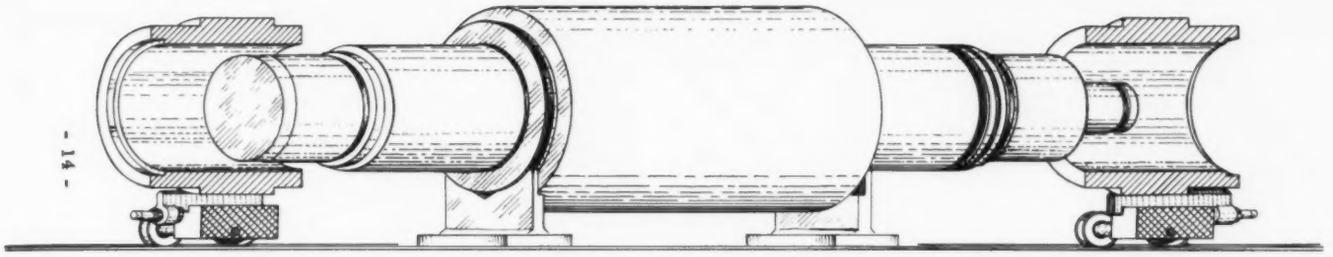


Figure 14 — A crane is not necessary for placing or removing bearings on or from the roll necks. The bearing change carriage shown requires no special operating skills or precautions.

space and clean working conditions are of paramount importance for optimum maintenance of the bearings, rolls, and chucks.

Where bearing men have been assigned to maintenance, they should, where possible, devote their full time to keeping bearing records and doing maintenance work.

Bearing operating auxiliaries—The maintenance of Mesta type oil bearings does not end when the backup roll assembly is placed in the mill. The following mill conditions and practices are important:

1. There should be individual sight flow indicators from each bearing on the mill. These indicators should be of such a design as to allow the detection of any faulty condition in any one of the bearings. A weir type sight indicator is desirable in that it allows the detection of the sudden ingress of water on wet mills. However, the water leg principle can also be used.

2. The flexible return line connection from the bearing should be of adequate size (approximately four times the area of the inlet) and should be lower than the bearing housing at all points. In other words, if the return line goes up hill as it leaves the bearing housing, oil will be trapped in the bearing at a level above the oil seal ring and the direct pressure on the ring will cause excessive leakage.

3. The inlet line should have adequate indication of temperature, pressure, and flow. A mere pressure gage is not always sufficient. One flow gage is a variable area metering device for indicating fluid flow rate. It has the advantage of being suitable for use with opaque liquids on applications where conventional sight flow indicators having glass windows or tubes would be hazardous or undesirable.

Spacers, retaining rings, gaskets and seal rings—Two seal rings are provided at each end of the bearing to retain oil and exclude foreign matter. The inner and outer rings of each pair are separated by a channel-shaped spacer ring, which serves to return any oil, which may have escaped past the inner ring, to the circulating system. The outer ring serves as a final check against oil leakage, and as a means of excluding water and dirt from the bearing.

The seal rings are bronze rings of rectangular cross section, split at one point to form snap rings. The outer circumference is grooved to accommodate helical garter spring. The ends of the garter springs are connected under tension in order to exert light radial pressure between the seal ring and the journal. Consequently, the seal rotates with the journal. The running clearances at the sides of the seal rings should be carefully controlled in order to maintain the specified tolerances.

For best results with the bronze seal rings, the following maintenance procedures are recommended:

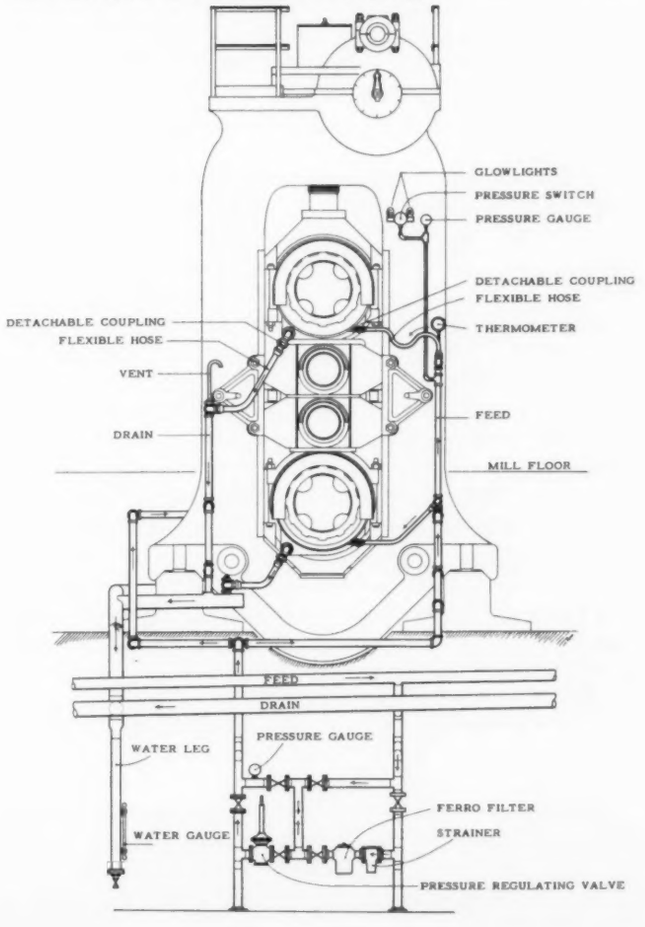
1. The bronze should be of a uniform fine grain quality, free of stress, with a Brinell of 65 to 70.

2. Chromium plating of the sides of the bronze ring is highly desirable; it provides a hard wearing surface between the seal ring and the spacer ring.

3. The gap at the split should have a clearance of 0.032 to 0.035-in. to assure that the garter spring holds the seal ring firmly against the roll neck. There should be no slippage or wear taking place between the ID of the oil seal ring and the journal.

4. The oil seal rings should be inspected on a machined flat plate to assure that the ring does not deviate from the surface plane by more than 0.0015-in. This is measured by a feeler gage not having sufficient space

Figure 15 — The operator's side of the mill shows the auxiliaries for the backup roll bearings.



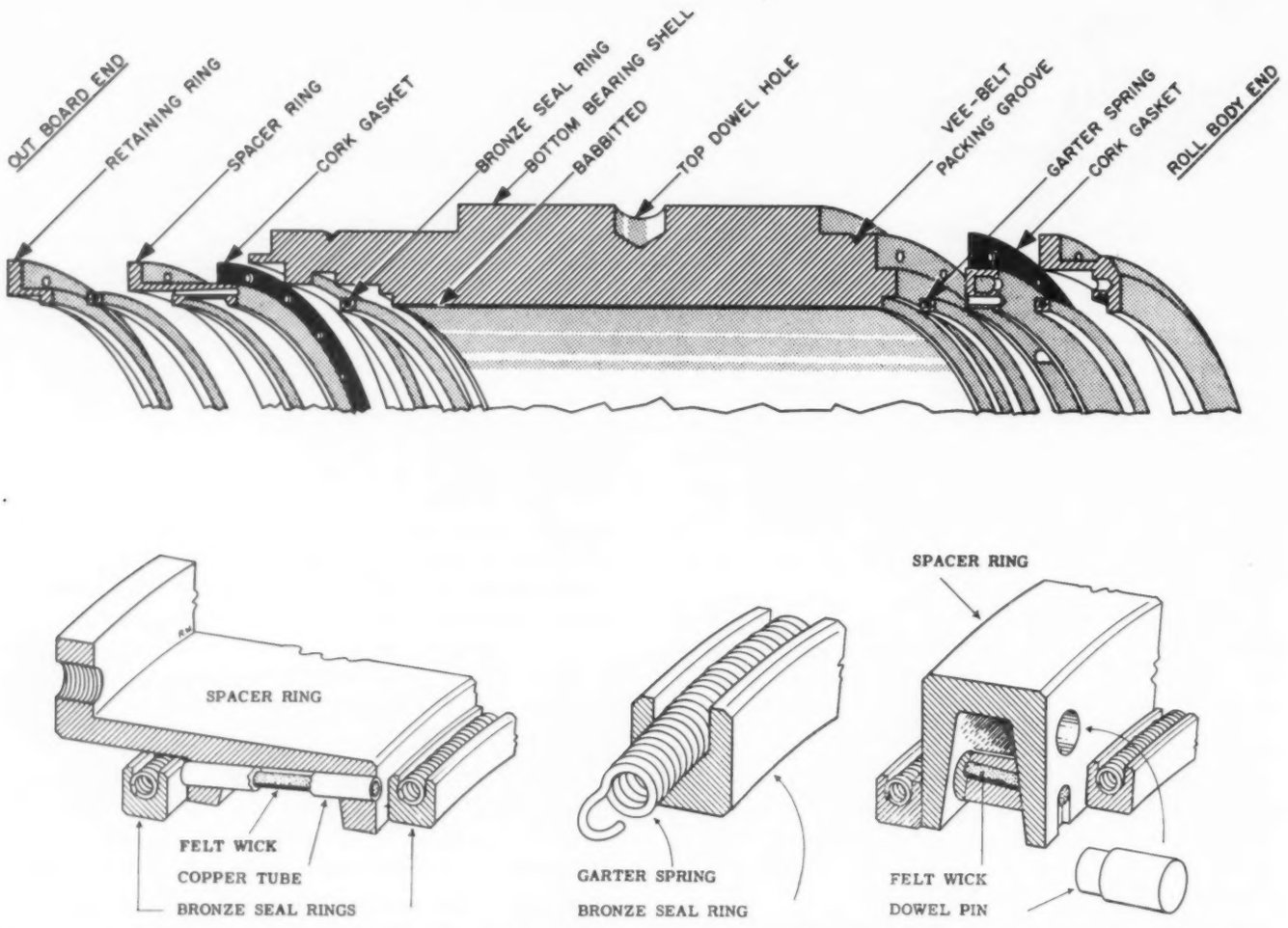


Figure 16 — The top view is an assembly view of the radial type roll neck bearing. The lower left detail shows drilling in the spacer ring with a copper tube filled with a felt wick to provide lubrication for the outboard seal ring. The lower right detail shows drilling in the spacer ring with a felt wick to provide lubrication for the roll body seal ring.

between the ring and the plate on any point of its circumference.

5. The oil seal ring should be checked on the roll neck with a feeler gage of 0.0015-in. not passing between the journal and ID of the ring at any point of its circumference.

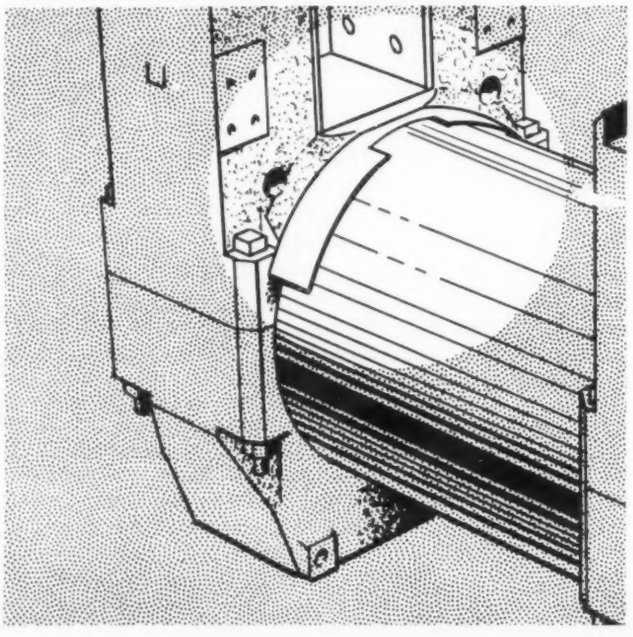
6. When the oil seal ring is assembled, the side clearance between the ring and the spacer should be between 0.004 to 0.006-in. on all rings. Care should be exercised in tightening the bolts on the retainer ring so as not to distort or hinder in any manner the free movement of the oil seal ring in the grooves provided by the spacer rings.

External seals and water deflectors—Both hot mills and cold reduction mills are now operating with roll coolant or other sprays at pressures and volumes far beyond what was previously considered normal. It is therefore more and more necessary to keep off the direct application of high pressure sprays on certain bearing chuck parts by using baffles or deflector plates. We should remember in this connection that high water content in the lubricating oil is usually synonymous with high oil leakage.

The most obvious precaution is to direct sprays to the roll bodies or to the strip, with as little coolant as possible directly striking the junction area between the backup roll neck and the roll body.

Simple sheet metal deflectors have been installed in the field as illustrated in Figure 17 to deflect both scale and water. These have the advantage of doing an effective job, with a simple means of adjusting or bending the baffle after new rolls have been placed in the mill.

Figure 17 — To deflect scale and water away from bearing seals, sheet metal deflectors have been installed on mills.



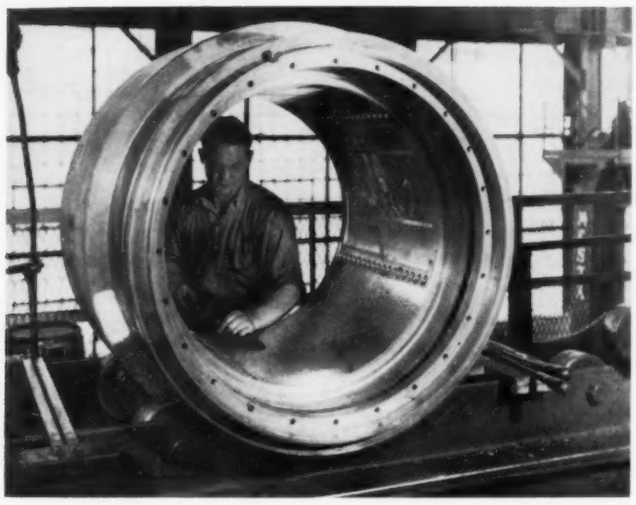


Figure 18 — When bearings are removed from their roll necks, the main journal on the roll neck should be inspected for wear.

Such deflectors are highly recommended on all wet mills.

Roll shop practice—Usually, roll bodies are ground with the bearings on the necks. For safety reasons, the oil inlet pipe should first be unscrewed from the shell. To keep the bearing sealed tightly against entrance of grinding solution and to keep the bearing from turning on the neck, the tap bolts (part 28 of the List of Parts) should be removed and the collar nut (part 24) should be screwed up against the bearing shell, forcing the shell tightly against the roll body. Finally, to keep solution out of threads of the locking rings, friction tape or packing material should be used to temporarily cover or fill up the gap between the collar nut and the adjusting ring (part 26). All ball checks should be tight on their seats.

Where bearings are removed from necks for bearing maintenance purposes, Figure 18, the main journal on the roll neck should be inspected for wear or damage over the working position of the bearing as well as over that portion where seal rings are located. Surface defects on the neck should be corrected, as it is desirable that the neck be cylindrical and with a surface polish normally obtained when new with a 320-grit grinding wheel.

Roll necks should be lightly oiled after cleaning up and covered with a tightly-wrapped band of paper to keep out dirt until the bearing is returned to its particular roll neck.

TYPICAL LIST OF PARTS FOR MESTA STANDARD OIL BEARING

(Sizes 36 x 30 in., 33 x 28 in., 30 x 25 in.)

Part number	Quantity per bearing	Description
		Bearing proper
1	1	Cast iron ring spacer and felt wick
2	1	Cast iron or cast steel retainer
3	1	Cast iron ring spacer, including copper tubing and felt wick
4	1	Cast iron retainer
5	1	Cork gasket
6	1	Cork gasket
7	24	Steel cap screws
8	1	Steel dowel pin
9	1	Steel check
10	24	Steel Allen cap screws
11	8	Steel Allen cap screws
12	12	Hard steel wire, ⅛ in.
13	1	Brass spring
14	1	Steel finished ball
15	1	Malleable iron 1-in. pipe cap
16	2	V-belts for packing
17	4	Nickel bronze rings (chrome plated on sides when specified)
18	4	Steel garter springs
19	4	Steel ball seat
20	4	Bronze special balls
21	4	Steel pins
22	4	Steel pipe springs
23	1	Steel 1-in. pipe
24	1	Steel collar nut
25	1	Steel collar
26	1	Steel adjusting ring
27	1	Steel split ring, complete
28	8	Steel tap bolts
29	1	Bottom bearing shell, babbitted
		Parts associated with bearings
41	1	Dowel pin, top
42	1	Dowel pin, bottom
43	4	Hex nut
44	4	Turned through bolt
45	1	Pressure block (bottom chucks only)
46	1	Liner (bottom chucks only)
47	..	Mill housing
48	..	Portion of roll neck for roll grinding
49	1	Bottom box—bottom half
50	1	Bottom box—top half
51	1	Key
52	1	Thrust bearing bracket
53	1	Cover
54	1	Thrust clamp
55	1	Thrust bearing
56	2	Bronze rings
57	2	Cast iron seal ring
58	8	Square head through bolt
59	8	Hex nut for through bolt
60	..	Roll body

Storage of bearings and parts—Although there is sturdiness in the assembled bearing, the individual parts are still precision made. The method of storing both the bearings and the parts should therefore be appropriate for precision-made materials. Some improperly stored items will as surely "wear out" as when they are in normal use.

When the assembled bearing is not stored on a roll neck, with all check valves automatically closed, it should be stored in or near the roll or bearing shop where conditions are reasonably clean and dry. Large wooden disks, with diameters about equal to that of the OD of the bearing shell should be bolted with through bolts, or equivalent, to tightly cover the open ends of bearings. The practice of stuffing rags in the bearing openings is not recommended.

The large individual parts kept in storage include spacer rings, retainer rings, oil seal rings, garter springs, cork gaskets and locking rings. It is recommended that these parts be stacked in a horizontal position. It is also important that the parts not become damaged while stacked flat in individual clean storage bins. Seal rings, for example, can be rendered unfit for bearing use by relatively slight bumps.

Lubrication methods and tests—The lubricating oil for Mesta type oil bearings comes under a general classification of nonadditive circulating oil. The application of circulating system oils is the lubrication or precision type journal bearings where extreme pressure additive lubricants are not required. This service is subjected to large quantities of water, rolling solution, dirt, scale, heat and boundary lubrication. The method of application is pressure circulating pumps from storage tanks

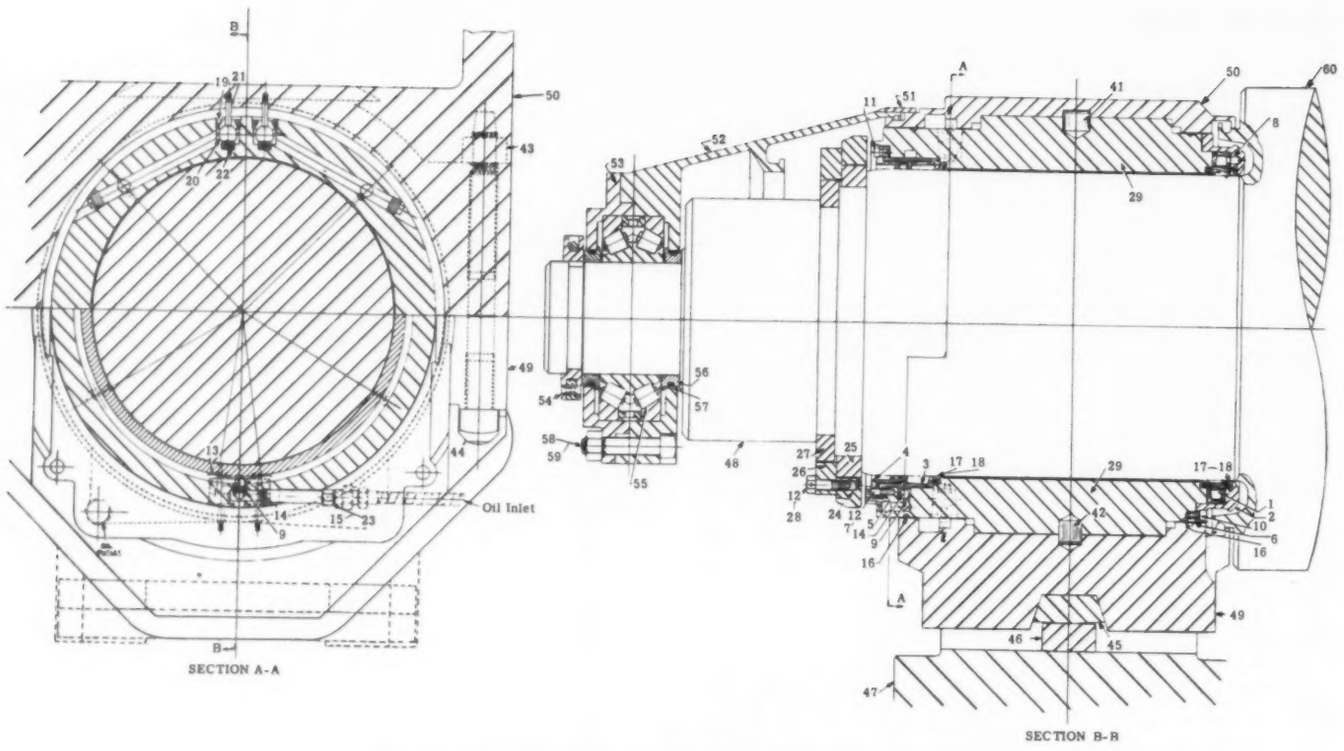


Figure 19 — Assembly drawing radial oil-film bearing.

where the lubricant is reconditioned by settling, centrifuging and filtering.

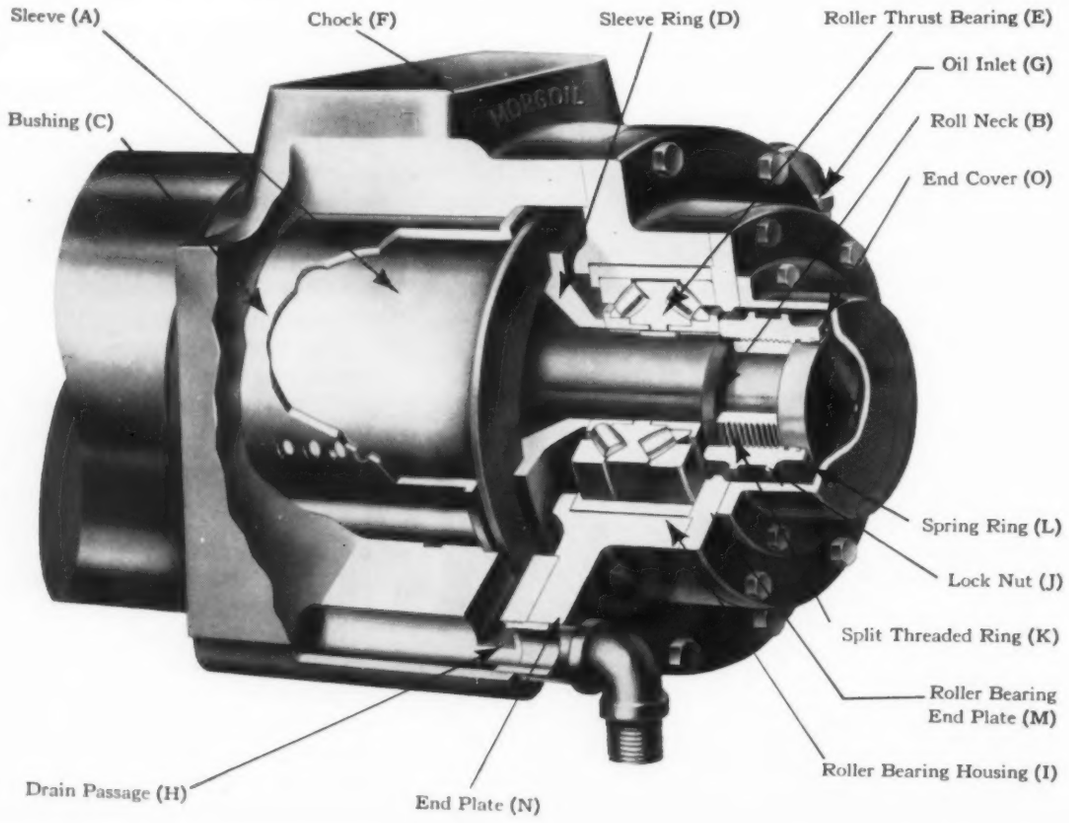
The physical properties of the new oil should have the following minimum requirements:

Viscosity ASTM D-88. Since the required viscosity of oils used for bearing lubrication is a function of roll speed, rolling load, bearing clearances and other factors, each case must be considered individually. However, oil viscosities for the oil bearings on typical 4-high mills usually fall within the following ranges:

Hot mills: 2100 to 2400 SSU at 100 F.
Cold mills: 1400 to 2400 SSU at 100 F (or even lighter).

Gravity ASTM D-287. Not less than API 25.

Figure 20 — A roller thrust bearing is used on tapered neck bearings 21 in. and larger.



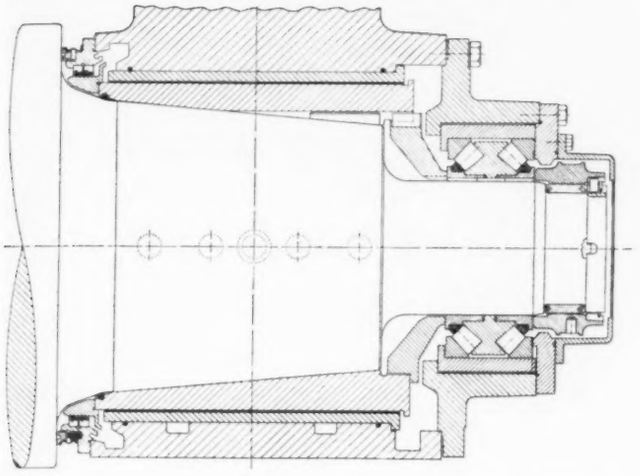


Figure 21 — Cross-sectional view of tapered neck bearing.

MORGOIL BEARINGS

In the 1920's the Morgan Construction Co. experimental work was started with a sleeve type, oil film bearing, operating with hydrodynamic lubrication. The first installation went into operation in 1932 on a 2-high hot strip mill.

Morgoil bearings, Figure 20, are precision built throughout and must be handled carefully. Their maintenance should be the responsibility of a special bearing service group working in a separate dirt free area where the bearings can be serviced and stored.

Description—The principal parts of the Morgoil bearing are few and are of simple construction. The sleeve is an alloy steel forging, heat treated and ground to a mirror finish of approximately 2 to 4½ micro-inches, root-mean-square as measured by profilometer. The sleeve has a taper bore which fits on and is keyed to the tapered roll neck, thus becoming the journal. Surrounding the sleeve is the bushing, which is a steel shell lined with centrifugally cast, cadmium-nickel bearing metal, babbitt or a solid aluminum alloy, accurately bored to give a highly finished bearing surface which carries the radial load. Adjacent to the outboard end of the sleeve is the thrust bearing which is either a double-acting roller or ball bearing, depending on the size of the radial bearing. The thrust bearing is independent of the radial bearing and can adjust itself to roll neck deflection and other types of misalinement common in rolling mill work. Earlier designs employed plate type thrust rings.

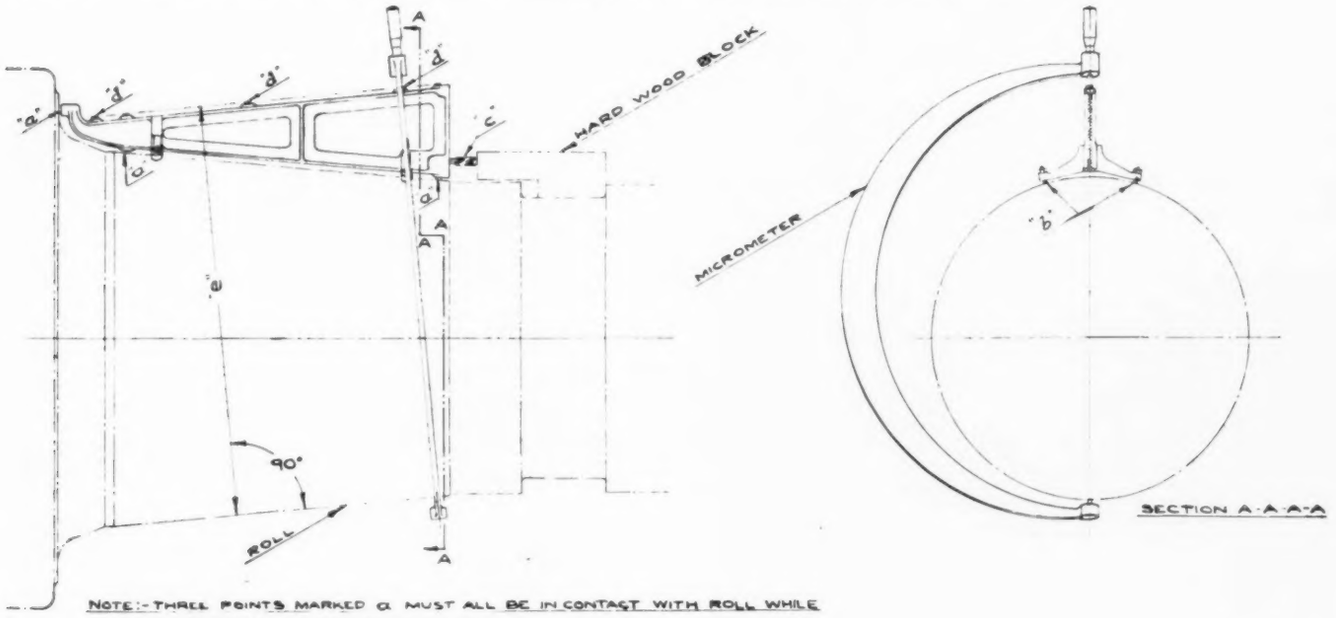
These principal parts with enclosing chock and the all important oil and water seals and end plates make up a compact roll neck bearing. The assembly is secured to the roll neck by a lock nut engaging a split, threaded ring, and is mounted and removed as a unit.

The manufacture of the rolls—Rolls to be used with Morgoil bearings should be mounted on centers for the turning and grinding of the journal portion of the roll necks. The roll is then mounted on bearing pads for turning and grinding the balance of the necks and body.

All dimensions of the roll must be machined as accurately as possible, *the body length must be exact*, and the *tapered necks must be held within the tolerances* shown on the manufacturer's drawings. Gages are manufactured for the machining of the taper. The method of using the gages is shown in Figure 22. With proper care, it should not be necessary to regrind the roll necks during the life of the roll.

An important responsibility of the bearing service personnel is a close dimensional check of the tapered

Figure 22 — This diagram shows the method of using taper roll neck gage bar with micrometer.

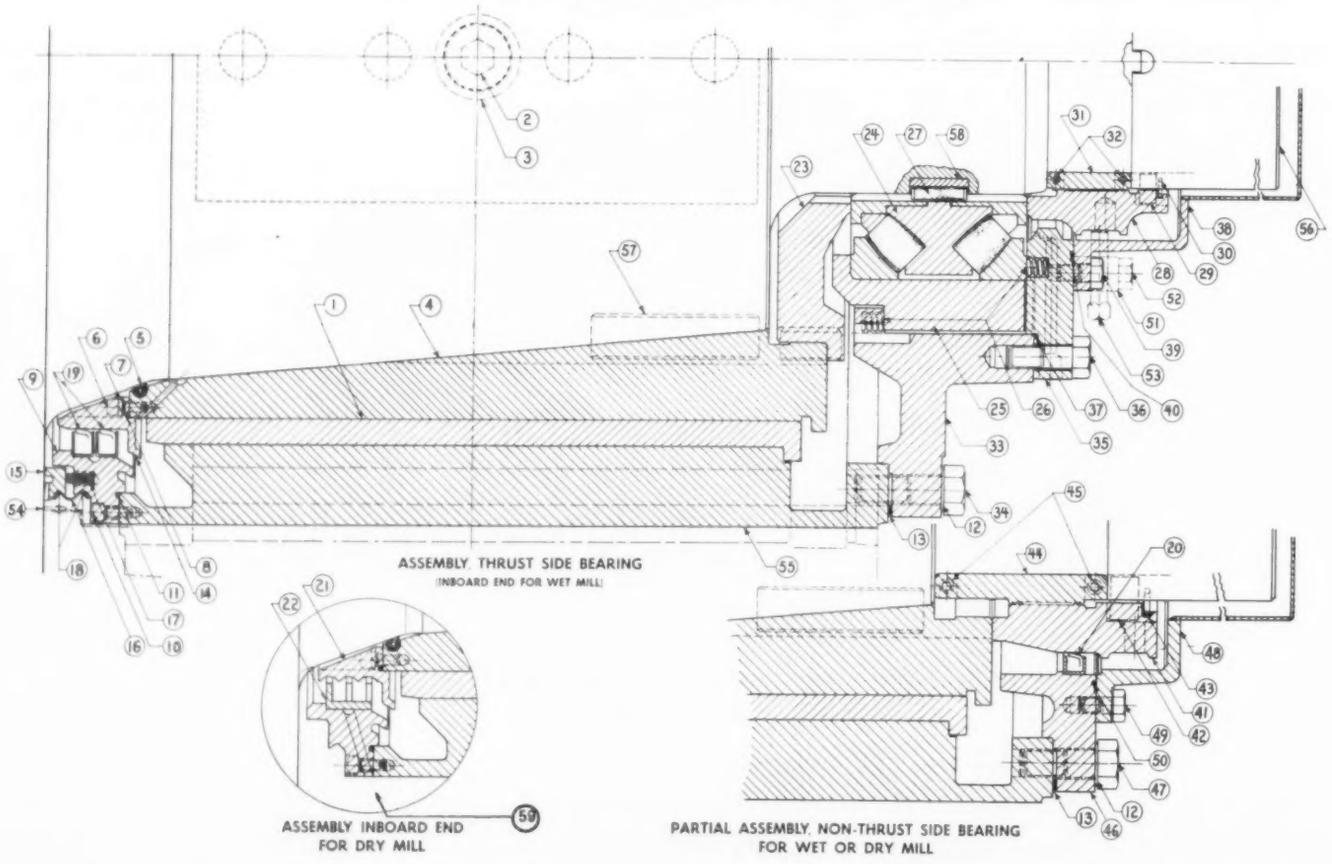


NOTE:- THREE POINTS MARKED a MUST ALL BE IN CONTACT WITH ROLL WHILE MEASUREMENTS ARE BEING MADE.
SETSCREWS MARKED 'b' SHOULD BE ADJUSTED TO CLEAR ROLL BY APPROXIMATELY 1/64".
TIGHTEN THUMB SCREW 'c' ONLY ENOUGH TO MAINTAIN CONTACT BETWEEN ROLL & PINS a.
THREE POINTS MARKED 'd' ARE TO BE USED FOR MICROMETER MEASUREMENTS.
FOR DIMENSION 'e' SEE DRAWING OF ROLL OR ROLL NECK.

Figure 23 — Parts of a disassembled tapered neck bearing.

roll necks and the roll body length. This is of particular significance since the work side and drive side chocks, containing stationary bearing parts, are fixed in position in relation to mill housings by housing keepers, or latches, or by other means, to guarantee the desired center-to-center distance of bushings. Therefore, corresponding accurate centerline-to-centerline distance between roll neck journals must be maintained. In the event of either a shorter or longer roll body (or taper necks ground undersize or oversize) the taper bored ro-

Figure 24 — Assembly drawing of tapered neck bearing.


ASSEMBLY, THRUST SIDE BEARING
(INBOARD END FOR WET MILL)
ASSEMBLY INBOARD END
FOR DRY MILL
PARTIAL ASSEMBLY, NON-THRUST SIDE BEARING
FOR WET OR DRY MILL

tating sleeves would position improperly and might cause endwise interference between flanges on the sleeve and the bushings of the floating side bearings.

Description of the Morgoil bearing—parts and procedure to be followed in its assembly—In assembling Morgoil bearings, Figures 23 and 24 and Table I, care must be taken to correctly identify and assemble the bearing for thrust side and for side-opposite thrust. Use drawings provided by the mill builder and the construction company.

Only one Morgoil bearing with thrust is used per roll and this is used on the side of the mill as specified by each individual mill.

In the following descriptions will be either the words "interchangeable" or "not interchangeable." This will denote that the parts are or are not interchangeable between the thrust side and the side-opposite thrust.

The casing (not interchangeable)—Identify from the mill builder's drawings. The casing, Figure 25, must be thoroughly cleaned and all preservative coatings removed. (Note—the oil sumps are painted with oilproof enamel which should not be removed.) Particular care must be taken to see that all holes are clean.

The casing should be placed in a vertical position on a relatively level surface. However, an alternate means as illustrated by Figure 26 may be used. The use of this turning device facilitates the handling of the casing into the proper working position.

The bushing packing (interchangeable)—This packing

TABLE I
Identification of Parts for Morgoil Bearings with Roller Thrust (Refer to Figure 24)

Parts, all bearings
1. Bushing
2. Bushing lock screw
3. Bushing lock screw washer
4. Sleeve
5. Sleeve packing
6. Sleeve extension screw
7. Sleeve extension lock washer
8. Sleeve extension packing
9. Inboard end plate
10. Inboard end plate bolts
11. Inboard end plate packing
12. End plate bolt washer
13. End plate packing

Parts, all bearings, wet mill only
14. Sleeve extension
15. Water seal ring
16. Water seal boot
17. Water seal spring
18. Water seal wire
19. Inboard oil seal
20. Outboard oil seal (not used when end cover, No. 48, is used)

Parts, all bearings, dry mill only
21. Sleeve extension
22. Grooved ring

Parts, thrust side bearings only
23. Sleeve ring
24. Roller bearing
25. Roller bearing housing
26. Roller bearing spring
27. Roller key
28. Locknut
29. Locknut key
30. Locknut key retainer
31. Pair threaded half rings
32. Threaded half ring screws
33. End plate

Parts, thrust side bearings only (continued)
34. End plate bolt
35. R. B. end plate
36. R. B. end plate bolt
37. R. B. end plate packing
38. End cover
39. End cover bolt
40. End cover packing

Parts, nonthrust side bearings only
41. Lock nut
42. Lock nut key
43. Lock nut key retainer
44. Pair threaded half rings
45. Threaded half ring screws
46. End plate
47. End plate bolt
48. End cover
49. End cover bolt
50. End cover packing

Parts, top bearings only
51. Locking block
52. Locking block bolts
53. Locking block setscrews

Parts, bottom bearings only, wet mill
54. Water guard

Miscellaneous
55. Bearing casings, top and bottom, thrust and nonthrust sides
56. Roll
57. Roll neck key
58. Key seat insert for roller key
59. Force feed lubricating system

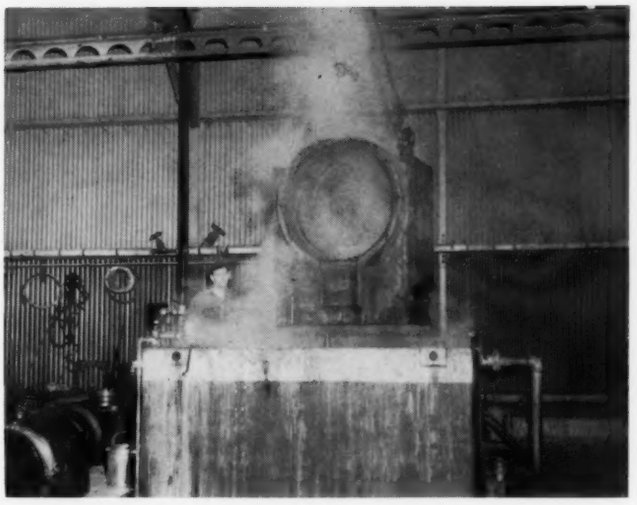


Figure 25 — The bearing casing is being cleaned.

is a neoprene tubing inserted in the circumferential grooves in the bore of the casing to prevent escape of oil between the bushing and the casing. The ends should be cut square to make a tight butt joint which should be located at the top of the grooves in the top casing and the bottom of the grooves in the bottom casing.

Bushing packing is currently used in bearing chocks in older installations, but has been eliminated in the more recent bearing designs; experience shows its use is unnecessary because no significant amount of oil passes between the bushing and chock bore. Elimination of the grooves in the chock bore gives better support to the bushing in the load zone area; and, when aluminum bushings are used, prevents possible extrusion of aluminum into the grooves, which may cause difficulty in removing the bushing from the chock and would make necessary the removal of extruded material before reusing the bushing.

The bushing (interchangeable)—The bushing, Figure 27, for the radial bearing is made of a special bearing metal. It should be thoroughly cleaned and oiled. A slow moving crane should be used for the assembly of the bushing in the casing. Long eye bolts with a piece of wood between, to prevent bending of the eye bolts, are threaded into the lifting holes provided at the outboard

Figure 26 — The use of this turning device helps to facilitate the handling of the casing into the proper working position.

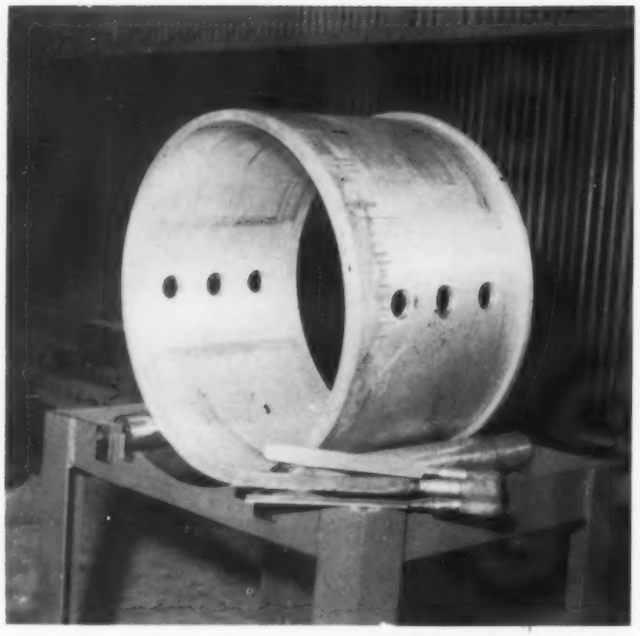


Figure 27 — The bushing for the radial bearing is made of a special metal.

end of the bushing. This permits lifting and lowering of the bushing into place. No force is to be used to fit the bushing in the casing and the side holes are to be kept in line with the large tapped hole in the side of the casing. Care must be taken to avoid scratching the bearing metal.

The manufacturer recommends long eye bolts with a wood spacer positioned between them to prevent bending the eye bolt. The same results can be accomplished and the operation speeded up by use of a small spreader.

Repairs can be made to wiped, or otherwise damaged, areas in bushing bores by using conventional type bearing scrapers, Figure 27. The size of the area which may be repaired without reducing the effectiveness of the bearing is limited relative to the size of the bearing itself. This is a decision which must be made in each individual case.

An ordinary grinder may be used to remove upset areas on the flange or shoulder, which are caused by sleeve interference at the outboard end of the bearing. The precaution of lining the bearing surfaces with oiled wrapping paper or canvas prevents grinding wheel particles from imbedding themselves in the soft bearing surface.

Aluminum bushings which were involved in a roll breakage at one mill distorted so badly that removal from chocks was difficult. This has led to the conclusion that the aluminum bushings, while showing excellent wearing qualities, would not stand the abuse of roll breakage, a known and expected hazard in 2-high primary mills. The result was the replacement of aluminum bushings with steel shell babbit lined bushings, instead of the now discontinued cadmium-lined bushings.

The bushing lock screw and washer (interchangeable)—This lock screw, which is a dowel to properly locate the bushing in the casing, is threaded through the large tapped hole in the side of the casing into the hole in the side of the bushing. Should these holes not be properly alined the bushing should be raised slightly and turned while raised until the holes are properly alined. Do not attempt to turn the bushing after it is all the way down in the casing. Place copper washer on screw, insert lock screw and tighten.

The sleeve (interchangeable)—The sleeve, which is the journal of the radial bearing, is highly polished on the cylindrical outside surface. The bore is tapered to fit the taper of the roll neck. The bearing manufacturer now furnishes a steel bar of rectangular cross section to lift the sleeve. The bar is turned on the ends to a diameter $\frac{1}{8}$-in. larger than the straight bore of the sleeve, and increasing at a taper of 2.15-in. per ft on diameter to fit the taper bore of the sleeve. A tapped hole is located dead center of the bar for an eye bolt.

Thoroughly clean the sleeve and oil both inside and out by the application of a thin film free of any foreign matter. *Do not use harsh abrasive materials.* Be extremely careful that the outer, highly polished surface does not become scratched. Lower the sleeve at least halfway into the bushing. Turn the sleeve until the keyway is on the centerline at the normal top of the casing; lower into place.

In many existing bearings, the inboard end of the sleeve is extended beyond the bushing; two rubbing seals ride this extension. In hot mill service, the abrasive action of scale gradually wears the sealing surface, resulting in faulty sealing. When this occurs, the manufacturer of the bearings can salvage the sleeve by machining off the worn section and securing a detachable sleeve extension to the sleeve. New sleeves can be purchased to include this feature. Chrome plating of the detachable sleeve extension is also recommended, as this will considerably extend the life of the seals.

Introduction of lubricant between the double seals also extends seal life. This can be accomplished through the use of a forced feed lubricator. See Figure 24. Since the seals are lipped toward the roll, the flow of oil is outward, thereby purging the water and scale from the seal area. This subject will be more thoroughly covered under the heading "Sealing."

The sleeve ring (not interchangeable—used on thrust side only)—This ring is a spacer through which pressure is exerted to tighten the sleeve on the roll neck. Pressure is exerted by the inner race of the thrust bearing and lock nut upon the sleeve ring. Eye bolt holes are provided in the outboard end for lowering into place. The ring is a close fit in the straight bore of the sleeve, and the key engages the keyway of the sleeve.

The thrust bearing assembly (not interchangeable—used on thrust side only)—This is shipped completely assembled. It should be disassembled, thoroughly cleaned, reassembled and oiled. The thrust bearing assembly is made up of the following parts: roller thrust bearing, roller bearing housing, springs, end plate, roller bearing end plate and packing (or in special cases, shims).

The roller thrust bearing (not interchangeable—used on thrust side only)—This is a steep-angle roller bearing. Its outer races are a close fit in the bore of the roller bearing housing. This bearing is double acting to take the full thrust load of the mill in either direction. If the component parts are not easily removed from the roller bearing housing, use the following procedure. Place the roller bearing housing on blocks, with the inboard end up, and the blocks positioned so that the bearing parts can fall out. Tap out the bearing parts using a copper

hammer or wooden blocks. (Note—for cleaning it is not necessary to remove the inboard roller bearing race.) Thoroughly clean the roller thrust bearing removing all grease or preservative.

The roller bearing housing (not interchangeable—used on thrust side only)—This housing is machined to give ample radial clearance in the end plate bore to avoid any radial loading of the thrust bearing. It is keyed to the roller bearing end plate to prevent rotation of the housing and outer race of the thrust bearing. Thoroughly clean the housing; carefully install roller bearing in the housing. It is important to maintain a close fit between the roller bearing and roller bearing housing. Thoroughly oil the complete assembly.

The springs (not interchangeable—used on thrust side only)—The springs absorb the slight clearances between the thrust bearing housing and the end plate, and between the outer race of the roller bearing and the roller bearing end plate. The purpose of these clearances is to prevent any radial loading of the thrust bearing due to the outer race and the roller bearing housing being clamped endwise. The springs also keep the unloaded race snug against the rollers while the other race is carrying the thrust load of the mill.

The end plate for thrust side (not interchangeable)—Thoroughly clean the end plate. Place on wooden blocks with the outboard end up. Place springs in holes provided. Pick up roller bearing housing containing roller bearing, using eye bolts in holes provided. Lower into end plate.

The roller bearing end plate (not interchangeable—used on thrust side only)—Thoroughly clean this end plate making sure that the oil supply hole is clean. If an oil seal is required, carefully install it with the lip pointing toward the roll body. Install roller bearing end plate packing in the groove of the end plate. Insert springs in the holes provided, using grease to hold them in place. Pick up the roller bearing end plate with a crane using eye bolts in holes provided. Lower into place on the end plate containing roller bearing and roller bearing housing. Make sure the key of the roller bearing housing is in the keyway of the end plate and that all springs have remained in the plate. Now determine the top of the end plate as it will be installed in the mill. Turn the roller bearing end plate until the oil inlet is pointing in the direction shown on the Morgan drawing entitled "Oil Piping for Morgoil Bearings."

Insert tap bolts provided and tighten in place. Using eye bolts in the lifting holes that are provided, pick up this end plate with thrust assembly utilizing a crane. Lower it partially into place until all the tap bolts with copper washers on them can be started in the tapped holes in the end of the casing.

The end plate for side opposite thrust (not interchangeable)—Thoroughly clean end plate. If an oil seal is required, carefully install it with the lip pointing toward the roll body. Using the crane pick up the end plate and lower it partially into place until all the tap bolts with copper washers on them can be started in the tapped holes in the end of the casing.

The end plate packing (interchangeable)—This packing is solid round neoprene and should be inserted between the end plate and the casing outside of the bolt circle. It should be so lapped that the end coming from the normal top of the bearing is on the outside and slightly below the horizontal centerline of the bearing. When this has been done, the end plate assembly can be lowered all the way and tightened into place. Rotate inner race of roller bearing so that the keyway is on the center line of the normal top of the end plate.

To permit the assembly of the following parts, the casing should now be placed with the axis or bore horizontal and the top of the casing up, Figure 26.

The sleeve packing (interchangeable)—The sleeve packing is neoprene tubing cut square on the ends and fitted snugly into a groove in the sleeve to prevent oil leakage between the sleeve and roll neck. The use of this packing will be discussed further under the heading "Sealing."

The sleeve extension with flinger (interchangeable)—This sleeve extension provides an easily replaceable wearing surface for oil seals on wet mills, or forms a flinger seal on dry mills. It should now be thoroughly cleaned and attached to the sleeve using packing, lock washers and screws provided.

The inboard end plate (interchangeable)—Furnished by mill builder.

For wet mills—(mills using water or coolant) oil seals are required. These are installed in the inboard end plate, lips in tandem, both pointed toward the roll body. The removable inboard end plate permits the replacement of seals by simply removing the end plate without further disassembling the bearings.

For dry mills—(mills not using water or coolant) a grooved ring is supplied instead of oil seals. Thoroughly clean the grooved ring and press it into the inboard end plate making sure that the cross drain through the grooves is located at the bottom.

Install inboard end plate packing in groove in the end plate. Attach inboard end plate to the casing using the screws provided.

The water seal (interchangeable)—The water seal is composed of a boot (leather, rubber or asbestos), small compression springs and a leaded bronze ring which is keyed to the end plate or casing. Wrap the boot around the outer surface (containing a circumferential groove) of the leaded bronze ring and tie in place with soft wire. The boot ends should be at the bottom with about 1-in. gap between the ends. Insert the springs in the holes provided; place the leaded bronze ring, mating the key on the end plate or casing with the keyway of the ring. Using soft wire, tie the open end of the boot in the circumferential groove of the inboard end plate or casing. The leaded bronze ring bears against the end of the roll body to reduce the amount of water that would otherwise reach the oil seals. Some water may pass between the ring and the roll body, but can escape at the 1-in. gap between the ends of the boot.

Under severe conditions of heat and scale a practice has been established of installing a water ring. This ring is fabricated from $\frac{3}{8}$-in. pipe with $\frac{1}{4}$-in. holes spaced about 4-in. apart around the edge of the bearing adjacent to the roll face.

The water guard (interchangeable—used on bottom casings only—furnished by mill builder)—When the mill requires a large volume of coolant, the mill builder provides water guards for the bottom casings only. This guard has a brass strip which bears against the end of the roll body and is bolted to the top of the bottom cas-

ing through slotted holes. The water guard is loosely installed and pulled all the way back from the roll barrel until the roll and bearing assembly are installed in the mill and keeper plates tightened. The water guard is then moved to bear against the end of the roll barrel and tightened in place. However, under severe conditions, large pieces of scale may rip the guard from the chock and have been known to create a hazard, inasmuch as there is a possibility of the guard jamming between the roll face and the bearing. If this occurs, the use of the water guard should be abandoned and the previously mentioned scale spray ring used.

The roll—The roll should be mounted on V-blocks or on a specially designed assembly rack with the roll neck keys on top of centerline, Figure 28. Check the projection of keys on tapered necks; the key surface must be parallel to the axis of the roll and the key must not project more than that specified on the drawing titled "Detail of Roll Neck." If projection is incorrect, remove key using threaded hole provided for jacking key and machine key or keyway to correct dimension. The roll necks should be thoroughly cleaned and oiled.

The threaded half rings (not interchangeable)—The threaded half rings should now be installed on the roll. They fit in the grooves of the roll neck and are held together with Allen head screws. They are keyed to the roll neck to prevent slippage.

The roller bearing key (not interchangeable—thrust side only)—This key is a hardened roller which is a loose fit in the keyways of the roll neck and the inner race of the roller bearing. Insert the roller key in the roll neck keyway.

Everything is now ready for the mounting of the bearing on the roll neck. A final check should be made to insure the positioning of the bronze ring of the water seal and the alinement of the sleeve and roller bearing keyways with their respective keys; the sleeve keyway with the roll key, the roller bearing keyway with the roller key. Pick up the casing and mount the bearing on the roll neck.

The locknut (not interchangeable)—After the bearing is on the roll neck, lightly coat the thread of the locknut with white lead and lubricating oil. Thread the locknut on the threaded half rings, and tighten the nut by hand. The final tightening is done by inserting a round steel pin in one of the holes in the periphery of the nut, attaching a cable to the pin and pulling up tight with a crane. When explaining how to tighten these large nuts, some mill people use the expression, "Pull up with a crane until you think it is going to turn over." For comparatively small sizes of Morgoil bearings, the manufacturer furnishes a wrench for the lock nut; the lock nut is tightened by hand.

Figure 28 — The roll should be mounted on V-blocks.

The locknut key (not interchangeable)—When the nut has been properly tightened, insert the locknut key in the keyway of the roll neck and the half round keyway of the locknut. This key is unsymmetrical and can be installed either way to suit the requirement of keeping the locknut tight. Should these not be properly alined, keep a strain on the cable with the crane and, with a hammer, tap the face of the locknut. This should make the nut move enough to aline the keyways. The key will prevent the nut from backing off during operation of the mill. It should never be necessary to use a sledge to aline the keyway, providing the bearing assembly is correct and the locknut and threaded half rings are in good condition.

The key retainer (not interchangeable)—The key retainer is a snap fit in the groove at the outboard end of the nut that prevents the locknut key from becoming dislodged during operation of the mill.

The end cover packing (not interchangeable)—This packing is solid round neoprene and, when required, is inserted in the groove of the end plate.

The end cover (not interchangeable)—This is the last piece of the bearing to be assembled and is bolted to the end plate.

Locking block and set screw (interchangeable)—They are used on the top roll only, and only when installing roll in housing or when changing rolls by "C" hook or porter bar. Although the manufacturers "section through bearing" drawing shows this assembly only on one side, it is used on both top bearings and is bolted into place after the end covers are removed. The purpose of this set screw assembly is to lock the casings to the roll, thus preventing the casings from rotating while changing rolls.

Assembly of bearings for side opposite thrust—The assembly of the bearing on the opposite end of the roll is the same as that outlined above, except that there is no thrust bearing.

Sealing—Four basic sealing devices are used on Morgoil bearings.

1. Sealing at the inboard end of the sleeve.

Inasmuch as the oil flowing from the bearing is not under pressure, the sealing at this point can be one of several types, each adapted to its particular type of mill operation.

(a) Older types of bearings were sealed, either on the OD of the sleeve or by a seal ring attached to or a part of the roll neck, with leather or synthetic rubber oil seals. Improvements have been made, first by the addition of a step on the sleeve and later, by a detachable step. This type of sealing is generally used in mills where rolling lubricant is used and/or when mill scale is present.

(b) Bearing sleeves with a permanent seal section may be modified by machining this section off and installing a detachable section. It is recommended that if this improvement is made, provision for a key between

the detachable section and the sleeve should be made when used in reversing mills; this prevents the seal section from shearing the small bolts which position it. A great increase in effectiveness of the seals and an increase in seal life can be obtained by chromeplating the OD of these detachable sections.

(c) A refinement of the detachable section is the addition of a flinger ring which serves as a baffle to prevent loss of lubricating oil. In mills where no lubricant is used over the rolls and product, such as skin pass and temper mills, this type of ring has been used very successfully with no rubbing seals. For the seals, a grooved labyrinth ring is substituted and no other sealing is necessary.

(d) It is recommended that all lip type seals, synthetic rubber or leather, be mounted with the lip turned away from the mating section in order to avoid damage to the seal in assembling.

2. Sealing between the bushing and the chock.

In older bearing installations, neoprene tubing is used in grooves in the chock bore at each end of the bushing to prevent oil, being fed to the bearing, from by-passing between chock bore and bushing. For this type of assembly, the tubing should be installed carefully to avoid bulging, which will impede the entry of the bushing, or stretching, which will cause the cut ends to separate when in operation, thereby permitting lubricant loss.

3. Sleeve packing.

The sleeve packing is a neoprene tubing which seals the inboard end of the sleeve and the area between the sleeve and the roll neck. It is extremely important that this tubing be carefully placed in the groove provided. The tubing should be inserted into the groove carefully so that there are no voids under it. The ends should be cut square at the point of joining and approximately 1 in. of overlap should be allowed before inserting the packing. This overlap should be crowded into the groove, so that when the roll is placed on the neck and tightened into position, there is no possibility of a separation at the ends of the tubing. Care should be used when mounting the bearing so that the tubing does not strike the roll neck until it is in its proper position, thereby avoiding tearing or causing the tubing to slip from its groove. The reason that this tubing must be installed with care is that this is the only area of the bearing at which oil can escape under pressure. Pressure at this point is caused by oil grooves on the ID of the sleeve that allow the oil, which is under great pressure from the rolling elements, to enter this area. Oil loss in this area can be great enough to necessitate the removal of the rolls from service.

4. Water seals.

The area between the chock and the roll face is sealed with a variety of sealing elements. The seal most commonly used, when rolling lubricant or coolant water is present, is composed of a bronze ring, a boot and compression springs. The seal is assembled on the chock and the bronze ring rides the roll face to prevent entrance of rolling lubricant, coolant water or mill scale into the area of the seals. The boot in this application can be made of neoprene for cold mills and an asbestos fabric for hot mills. These boots and rings should be carefully inspected and replaced, if necessary, after each roll change. On many installations of small bearings, sealing rings made of synthetic resin have been successfully used; recently the use of this material has been extended to some of the larger bearings.

Maintenance—Good maintenance is preventive, as well as corrective, and should be the responsibility of both the operating and mechanical departments. As applied to oil-film bearings, it is concerned with the proper mounting of the bearings in the mill housings, the condition of the keeper plates, clamps and latches, breaker blocks and rocker plates.

Clean lubrication must be introduced to the bearings at the specified temperature and in the proper quantity. This involves the circulating oil system, i.e., pumps, filter, cooler and automatic controls of temperature, pressure and volume. The condition of the drive equipment, together with operating practices, may result in extra stresses or thrust loads. These are matters which must be taken into consideration in order to obtain the maximum service from these bearings.

Electric welding around a mill can be a source of trouble if the welder's arc is remote from his ground. Evidence of this can be found on the surfaces of roll necks and the bores of sleeves in the form of small pits. Wherever this pitting is found on machinery it should be smoothed over. This pitting will be found in other parts of the mill machinery where there are minute clearances between two steel surfaces. *Welders should be given specific instructions to place the ground as close to the arc as possible.* Use a magnetic ground, rather than the clamping type, so that the ground can be attached to flat surfaces.

Shop conditions and procedures—Intelligence, cleanliness and good facilities are necessities for the proper servicing of rolling mill bearings. The care of the bearings should be delegated to men who appreciate good machinery and take pride in keeping it right. Permanent bearing service crews should be established to perform the required service work.

A good location for a bearing shop with adequate facilities is of next importance. Bearings should not be disassembled or stored on the mill floor, if a separate area removed from mill operations is available. If space is available in the roll shop, this would be an ideal location. Regardless of the location, bearing maintenance should be performed in a well lighted, dirt-free, heated building. The area should also have ample storage space for spare bearings where they may be kept clean and dry. Oil and water seals, packing, etc., should be stored in lockers. Car lining paper, which is available in most steel plants, can be invaluable in providing a clean place to stand disassembled bearing parts. It keeps the floor clean, while eliminating a safety hazard, by absorbing oil drippings while in use, Figures 28 and 29, and can be easily discarded.

The frequency of disassembly and inspection of Morgoil bearings can be established by experience only. Seal wear is the major factor in determining the frequency of disassembly, but it should not be the only consideration. Operating conditions may have placed excessive thrust loads, or misalinement may have caused damage to the bearing, which would require disassembly to make necessary repairs. The possibility of damage by such conditions serves to illustrate the necessity for continual awareness of mill operating conditions by the bearing shop personnel.

Figure 29 — Carbon-like deposits collect on the inside diameter of the sleeve due to rolling pressures.

Inspection and service of Morgoil bearings is comparatively simple. Upon removal from the roll necks, bearings should be disassembled, if possible under a slow moving jib or jib type crane, Figure 25, which may be hand operated by the bearing man. After the bearing has been disassembled the chock should be thoroughly cleaned, either by washing with kerosene or placing in a tank containing a solvent which will remove all mill scale, paint, etc., Figure 25. The sleeve and bushing should be inspected for evidence of foreign material which may have scratched the sleeve or imbedded itself in the bearing metal of the bushing. Upset areas in the soft shell of the bushing may be repaired by scraping with an ordinary bearing scraper, Figure 27. Any foreign material imbedded in the bushing should be dug out and the sharp edges left should be broken by scraping. It is difficult to specify the desirable time intervals between complete inspections of these bearings, as this depends on type and severity of service. Experience on a particular installation will be the deciding factor.

The bushing should be inspected for evidence of corrosion or etching due to acid in the lubricating oil. Most cadmium lined bushings will show evidence of corrosion or etching almost from the time they are placed into operation. A moderate amount of this type of discoloration is to be expected in all cadmium bearings and will not have a detrimental effect on its operation. Severe etching should be brought to the attention of mill maintenance or lubrication personnel for an immediate check of the mill oil system for excessive acid. The more recently used aluminum bushings and steel-backed babbited bushings are not subject to this corrosion.

Very little work other than thorough cleaning may be done to the sleeve. The one exception to the use of abrasive materials on Morgoil bearings is in the area of the ID of the sleeve. Carbon-like deposits collect on the ID of the sleeve, Figure 29, and on the roll neck, Figure 28, due to rolling pressures; they are pressure oxides. These deposits must be removed with emery paper or a fine hand emery stone, inasmuch as continued accumulation will destroy the taper fit required between the sleeve and the roll neck.

After such cleaning, the parts should be thoroughly washed with clean kerosene to remove all traces of grit. The thrust bearing should be disassembled at intervals for inspection. It should not be necessary to disassemble this bearing each time the basic bearing is disassembled unless the operation is one which has either high speed or excessive thrust conditions. Evidence of wear in the thrust bearing may be observed by examining the exposed roller ends without removing the bearing from the case. All springs and neoprene tubing should be replaced. The cover tap bolts should be inspected for necking caused by thrust loading; they should be replaced if there is any evidence of wear.

For mills operating with a high thrust load, difficulty may result from a stretching of the cover tap bolts; it is then advisable to obtain a stress proof bolt to replace those supplied by the manufacturer. All other parts, seals, bronze ring, sleeve extensions, etc., should be inspected and replaced if necessary before reassembly of the bearing.

In shops where a tank with solvent for cleaning the chock is available, it is advisable to repaint the chock after it is cleaned. Rocker plates should be inspected for wear and positioning before the assembly is returned to the roll neck. All parts in the chocks, as they are assembled, should be oiled with the same oil used in mill operation.

The bearing should be mounted on a roll which is the same temperature as that of the bearing. If the bearing and roll are not of equal temperature the bearing should be mounted on the roll, but the nut positioning the bearing should not be tightened for at least an hour. If the neck is much warmer than the bearing, the sleeve will become loose on the neck when the parts assume the same temperature during operation. If the bearing is much warmer than the neck, the lock nut will move the sleeve too far on to the taper; when the temperatures become equalized, the fit will be too tight and it will be difficult to remove the bearing from the neck.

It is desirable to maintain accurate service records of Morgoil bearing parts. Upon each card a complete history can be kept of the component parts of each bearing. Generally, bearing life is rated as a function of operating load and operating hours; therefore, this card system affords an accurate check of these factors, since both tonnage rolled and operating hours can be recorded for each component part. Due to operational load distribution, the relative location of the bearing in the mill is important; therefore, a record should be kept of the bearing location in the mill for each particular installation. It is particularly important that the bushings be rotated through 180 degrees periodically, insuring even load distribution. The bearing service records should include information concerning this rotation, in addition to notes on the work performed on each part and the date of service to these parts.

Figure 30 shows the precision measuring of the inspection equipment used by bearing shop personnel and Figure 31 shows the working tools and safety equipment.

The oil-film bearing itself is extremely rugged and will stand a great deal of abuse. However, the importance of good maintenance cannot be overemphasized. If the procedures set forth in this paper are carefully fol-

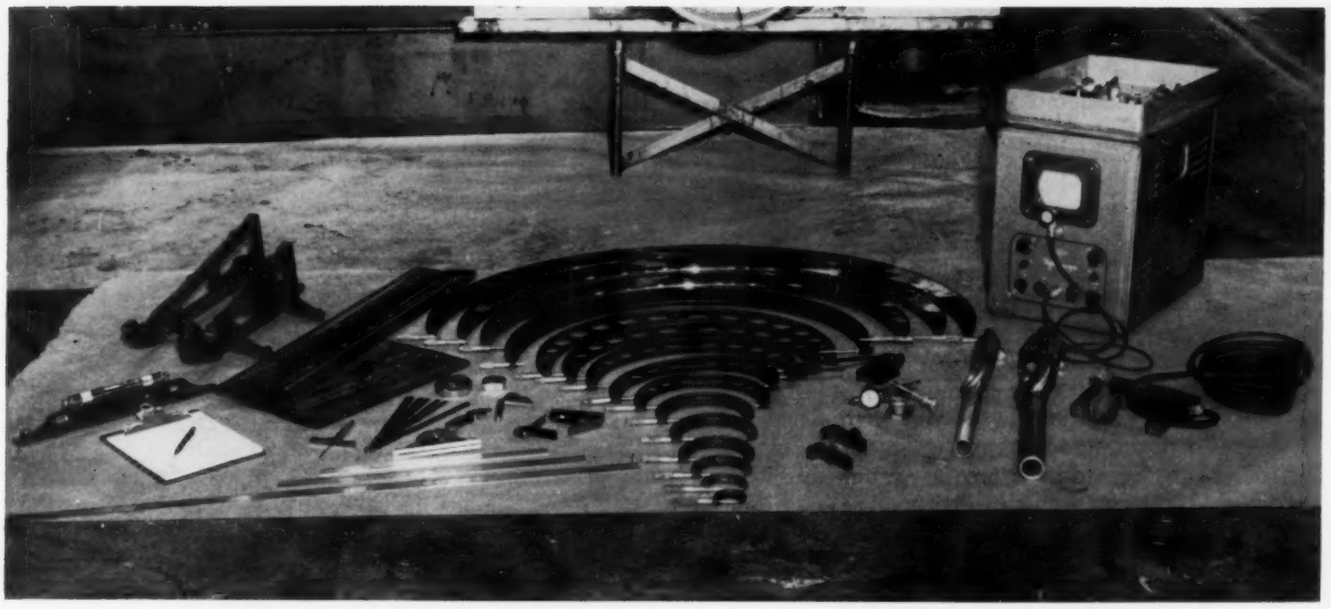


Figure 30 — Precision measuring and inspection equipment used by bearing shop personnel.

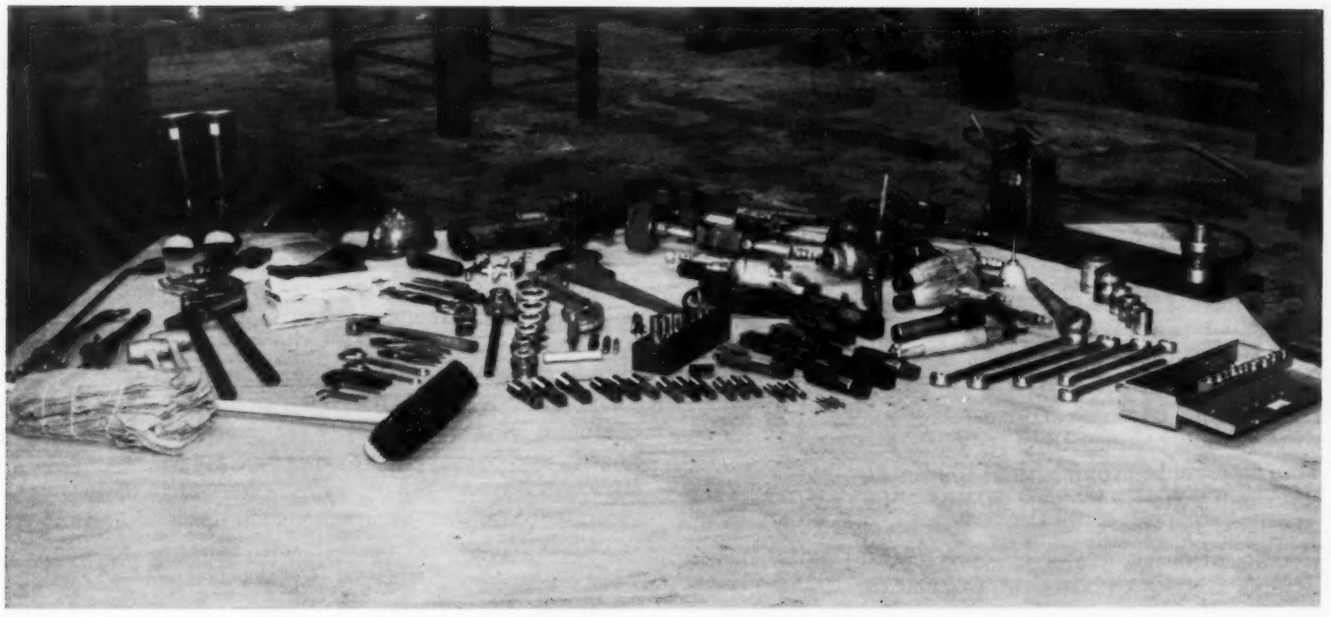


Figure 31 — Working tools and safety equipment.

lowed, the yearly replacement expense for well cared for bearings will be negligible.

LUBRICATION OF MILL OIL BEARINGS

The maintenance of mill oil bearings operating with hydrodynamic lubrication is not complete without proper consideration of lubricant selection and care. The development of hydrodynamic oil bearings since the 1930's has, for different applications, required lubricants of both higher and lower viscosities than formerly used. One manufacturer has described the lubricant requirements in the following manner.

Morgan lubricant specifications—The lubricant supplied to lubricate Morgoil roll neck bearings must be a high grade straight mineral oil, free from acid and other impurities, and must have a high resistance to oxidation and to the formation of sludge when subjected to hard service.

It must separate rapidly from water and other liquid impurities and must show a minimum demulsibility of 1620 at 130 F for oils up to and including a viscosity of 350 sec Saybolt Universal at 100 F. It must show a minimum demulsibility of 1620 at 180 F for oils heavier than 350 sec Saybolt Universal at 100 F. Demulsibility to be determined by Method 320.32. Demulsibility Test for Lubricating Oils as described in Federal Standard Stock Catalog, Section IV, part 5, VV-L-791b (February, 1942), pages 116, 117 and 118.

The viscosity of the oil to be used will be specified by the manufacturer, this specification giving maximum and minimum seconds Saybolt Universal at 100 F.

Minimum viscosity index (from Dean & Davis Chart) is 80 and this index is based on actual viscosity at 100 F and actual viscosity at 210 F.

The supplier of the oil must furnish to the purchaser and user at time of shipment of the oil, a sealed one-quart sample, representative of the oil shipped. This sample is to be taken from the oil when in bulk at the

refinery. The supplier must guarantee that this sample, when delivered with seal unbroken to a competent independent oil testing laboratory, will meet the viscosity, viscosity index and demulsibility and quality specifications given by the bearing manufacturer providing the tests are run within 30 days of delivery of the sample to the purchaser. It is recommended that the supplier of the oil keep a duplicate of the sample furnished his customer for a period of at least 30 days for check test purposes.

It is concluded from the manufacturer's recommendations that the most important properties required for the lubrication of mill oil bearings is that of lubricant viscosity and its ability to separate from water readily.

Some mills are equipped with a centralized circulating system. To insure proper lubrication to the mill, the practice of periodic checks on the system must be established. Matters to be checked are the condition of the filters and oil as well as oil supply, pressure, temperature, delivery rate, acidity, sludge and water content.

CIRCULATING OIL

General Requirement—Normal temperature, straight mineral oil with high stability and rapid water separation with correct viscosity for circulatory systems.
Oil viscosity D-88—Suitable for the application. 750, 1000, 1500, 2000, 3000 SSU at 100 F.
Viscosity index D-567—Not less than 80.
Open cup flash D-92—Not less than 350 F oils under 1000 SSU. Not less than 450 F oils over 1000 SSU.
Neutralization no. D-974—Not more than 0.100.
Pour point D-97—Not more than +20 F or lower depending on application.
Foaming—Nonfoaming or best separation possible.
Water emulsion—Best separation possible.
Oil oxidation by static oxygen—Not less than 24 hours for 60-mm pressure drop.
Four-ball weld—Not less than 100 Kg.
Four-ball wear—5 Kg load at 1 hr—Not more than 0.6 mm.
Coefficient of friction—Not more than 0.1 under conditions of wear test.
Field test—Satisfactory performance for the application intended.

Application—The principal application of circulating grade oil is the lubrication of oil film backup roll bearings. The service is subjected to large quantities of water, rolling solution, dirt, scale, heat and boundary lubrication. The method of application is pressure circulating pumps from storage tanks where the lubricant is reconditioned by settling, centrifuging and filtering.

Other applications include reduction gears and bearings where extreme pressure oil is not required, air compressor cylinder lubrication where detergent oil is not required and gas engine cylinder lubrication. In the last two applications, the oil is applied through force feed lubricators.

Discussion

PRESENTED BY

S. S. RICKLEY, Representative, Morgan Construction Co., Pittsburgh, Pa.

A. C. COOPER, Superintendent of Roll and Tool Shops, Lorain Works, National Tube Div., United States Steel Corp., Lorain, Ohio

S. S. Rickley: I would like to underscore the need for mill maintenance, roll alinement, and the necessity of a proper lubricating system. Too many mill operators have neglected the importance of mill maintenance as a factor in bearing performance.

In some cases the pattern seems to be that the new mill is started and does a good job for a few years. In due time, wear or damage has affected the proper functioning of keeper plates, breaker blocks, screw ends, and rocker plates. The lubricating system, the filters and the oil itself were neglected. The disregard of mill maintenance finally causes a bit of trouble.

The paper that was presented brings out that good maintenance can really make a fine performing mill over a good number of years.

I was very interested in the device that was shown for turning large bearing casings from the normal horizontal bore position to the vertical and back again. I do not think I have seen such a device in other shops, but it is recommended to other bearing users.

From the paper, it was very apparent that they did a wonderful job of maintenance in their shops, and I think it really paid off.

You mentioned the importance of the roll body length. I would like to ask just what tolerance you specify on roll body length and what you accept in your shop?

A. C. Cooper: We will accept minus $\frac{1}{16}$ in., and we can go as high as plus $\frac{3}{16}$ in. The clearance between the sleeve and bushing increases as the roll body gets longer. It is only on the minimum side where there is a danger of difficulty, due to sleeve and bushing interference. ▲

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Many problems, particularly refractory destruction, are encountered in using electric arcs to melt and refine steel . . . . photographic and tabulated data have explored the relationship of arc characteristics as a source of these problems.

Electric Arc Furnace Analysis Via Photography

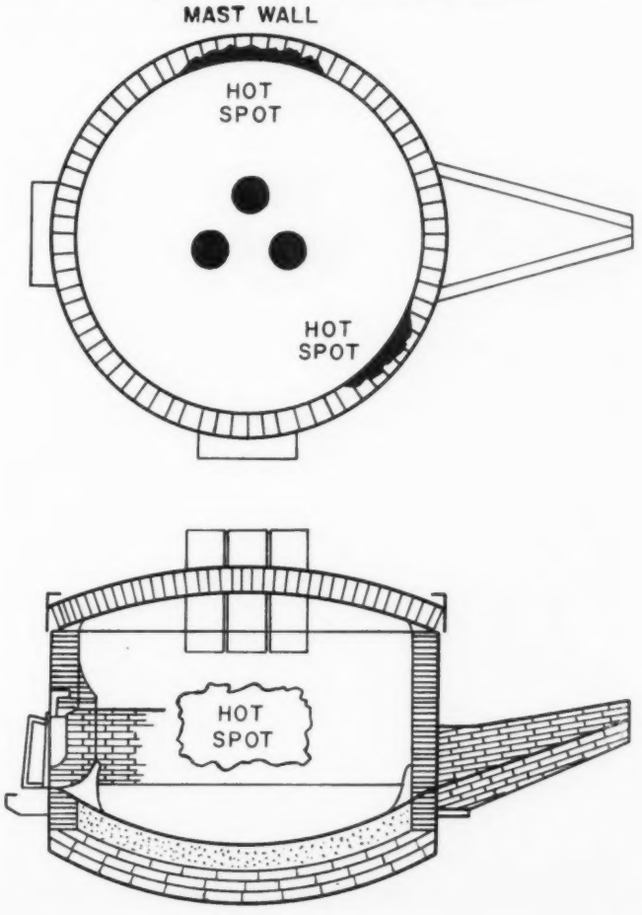
by J. A. Brosovic,
Electromechanical Research Center, Republic Steel Corp., Cleveland, Ohio

ELECTRIC arc furnace operations in the steel industry have experienced an intensive growth period during the last few years. Furnace capacities are nearing the 200-ton mark while transformer capacities of 36,000 kva and graphite electrodes as large as 24 in. in diam have already become commonplace items in some melt shops. Furnace practices have broadened to include the production of almost all grades of steel. Simultaneously with this growth, furnace operating and maintenance problems have become more serious and costly. In many cases, these problems have grown from insignificant routine tasks to a level requiring considerable attention and expense to make them tolerable.

Fortunately, as both the electric arc furnaces and their inherent problems have grown, the scope of technical services and facilities capable of coping with these problems has also grown. Instrumentation, previously restricted to the laboratory, has been made mobile for quick transportation to production locations, thus providing a means by which the conditions surrounding the problem can be accurately and extensively surveyed. For example, photographic equipment, previously too fragile for steel mill use, has been made more rugged and can now move in to record the conditions surrounding the problem from close-up vantage points too hazardous for human observers. Also, data processing systems, previously restricted to accounting work, have been adapted to eliminate the time-consuming task of calculating, tabulating and plotting the pattern of conditions surrounding a problem.

This paper covers the co-ordinated approach used by production, maintenance and laboratory personnel

Figure 1 — Hot spots, typical locations of which are shown, had become so serious as to justify the use of super refractories and installation of water-cooling pipes.



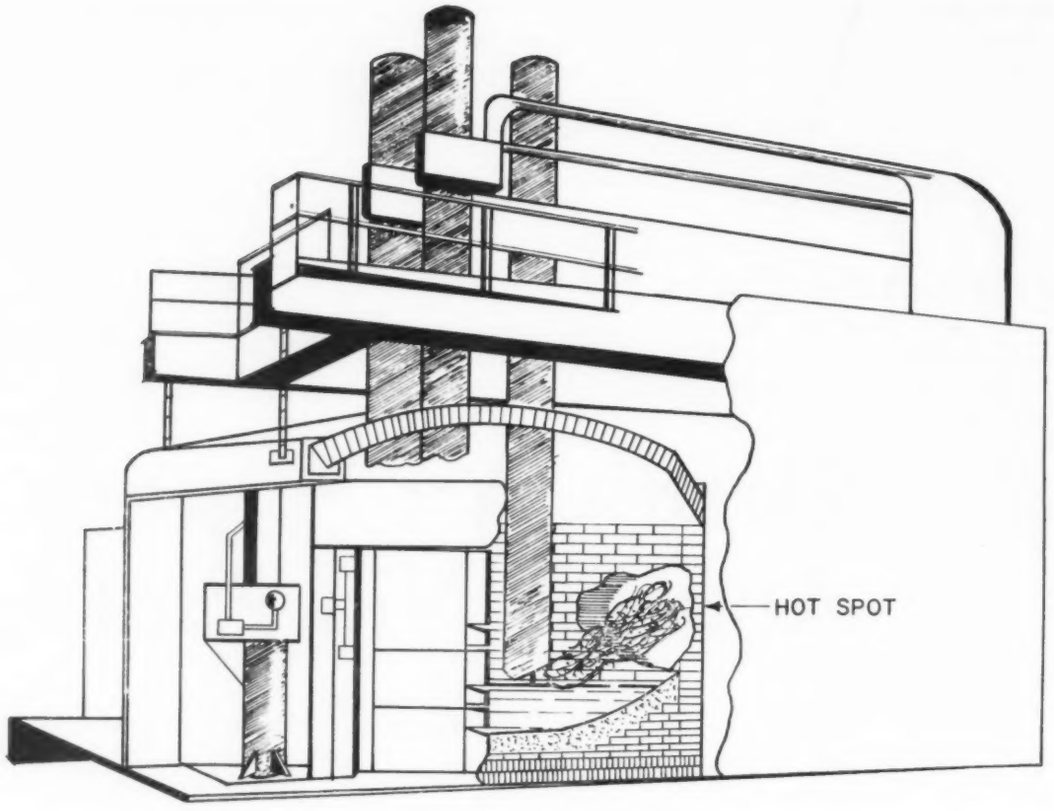


Figure 2 — The factors contributing to accelerated refractory failures were exposure to high impact loads, and sustained and uncontrolled attack by gas, dust, volatile matter, small high-velocity matter particles and radiant heat.

to isolate the cause of a serious refractory maintenance problem and to devise a preventive maintenance technique capable of reducing its ill effects to a tolerable level.

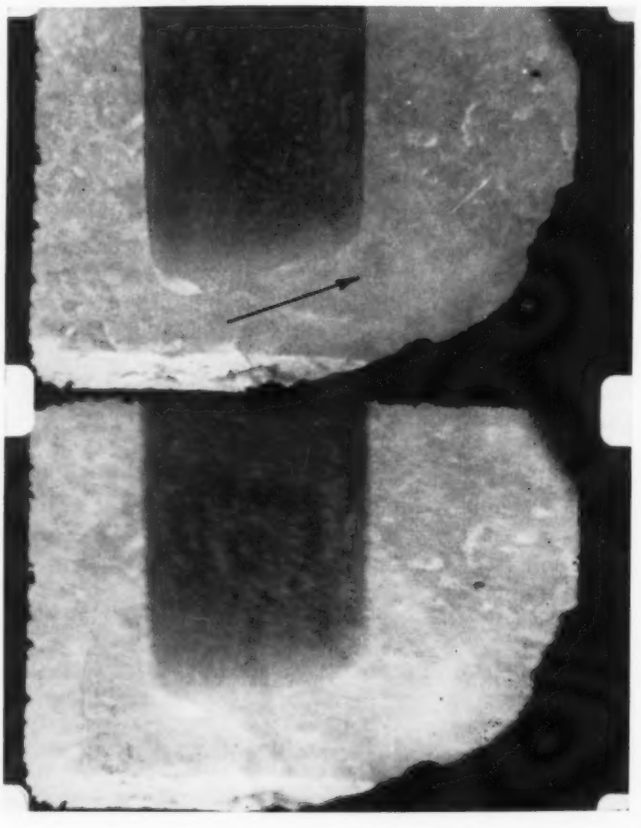
The specific problem examined by the group just mentioned was the occurrence of refractory lining "hot spots" in areas of the lining located above the slag line, Figure 1. At these points, refractory materials of all types experience an extremely short life span. Almost continuous patching between heats is required. Unscheduled shutdowns often occur during the course of a lining campaign for the purpose of replacing brickwork destroyed in these hot spot areas. The exact location and severity of the hot spots vary with individual furnaces and furnace practices thus adding to the difficulty encountered by masonry departments in prescribing suitable refractories for hot spot service. It is sufficient to say that, at the start of this investigation, the hot spot problem had become so serious as to justify the cost of installing expensive super refractories and water cooling pipes in an attempt to extend refractory life in the affected areas.

The first stage of the operational plan of this investigation was centered on exploring the environmental conditions surrounding a hot spot area. The key factors believed to be most capable of causing accelerated refractory damage in these areas were:

1. Exposure of the hot spot area to high impact loads such as might occur during top charge scrap drops.
2. Exposure of the hot spot area to sustained and concentrated attack by gas, dust, volatile matter, small high-velocity molten particles or radiant heat energy, Figure 2.

The actual mechanics of refractory destruction proceeds by way of many complex chemical, thermal and mechanical processes. Each of these processes is too complex for discussion in this paper. The effectiveness, however, with which each process can accelerate re-

Figure 3 — The electrode tip configuration appears to be the controlling factor in directing the destructive energy toward the hot spot area. The arrow indicates the direction of the hot spot.



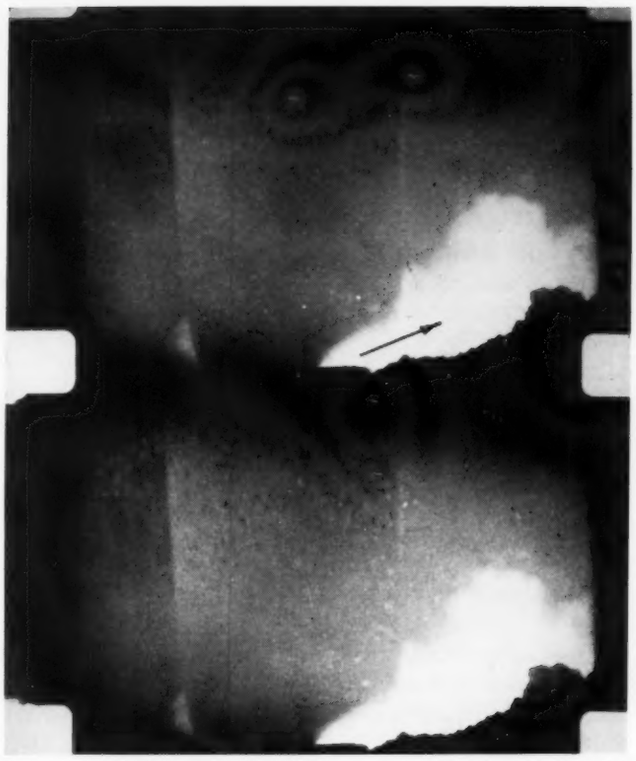


Figure 4 — This is a movie sequence of gas, dust and volatile matter traveling in the direction of the arrow to the hot spot.

fractory destruction is determined by the interrelationship of the key factors just mentioned.

The first of these factors, high impact loads, can in most cases be ignored as a direct cause of hot spots. Performance reports assembled by the furnace crews and maintenance personnel revealed the existence of hot spots of equal severity on side charge furnaces which do not experience scrap drops. Similar, but less severe, hot spots have also existed in furnaces using a high percentage of hot metal charge and also those involved in duplexing operations. It is possible, however, to inflict severe damage to any portion of a lining if it is struck by a scrap drop. Therefore, in certain cases, hot spot area destruction may proceed more swiftly because of this type of supplementary mechanical destruction of the refractory materials.

The other factors suspected to cause hot spot damage are concentrated attacks on the refractory lining by gas, dust, volatile matter, small high-velocity molten particles and radiant heat energy. Visual observation of both the interior and exterior of the furnace during the course of any heat will quickly verify the existence of each of these conditions. Normal and high-speed photographic analysis of the hot spot areas within the furnace, however, revealed a concentration of each condition existing in the hot spot areas. In each case, the arc zone, i.e., the area where electrical energy is converted into heat energy, appears to both create the condition and also supply the motivating force necessary to propel it into a hot spot area. The electrode tip configuration forms the chamber within which these forces are generated by the arc and the orifice which directs them toward the hot spot area.

Oxidation, vaporization, dissociation and reduction of the various materials in the arc zone are the predominant sources of gas, dust and volatile matter. Physical forces generated by these reactions along with strong magnetic fields surrounding the arc are believed to supply sufficient force to disturb the bath and slag surfaces, and generate frequent sprays of molten particles. Rapid changes in the distance between the electrode tip and bath surface regularly develop long exposed arcs capable of supplying large amounts of

Figure 5 — This movie sequence shows molten particles traveling toward the hot spot in the direction of the arrow.

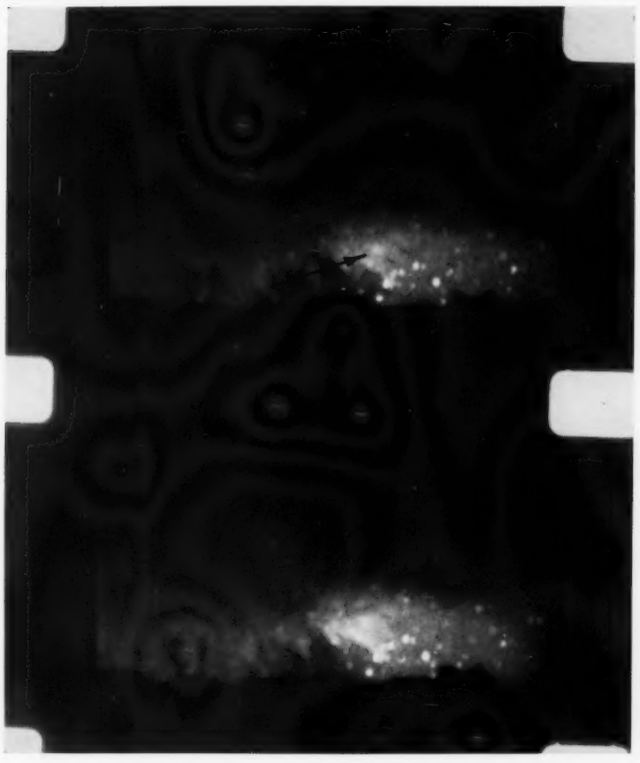
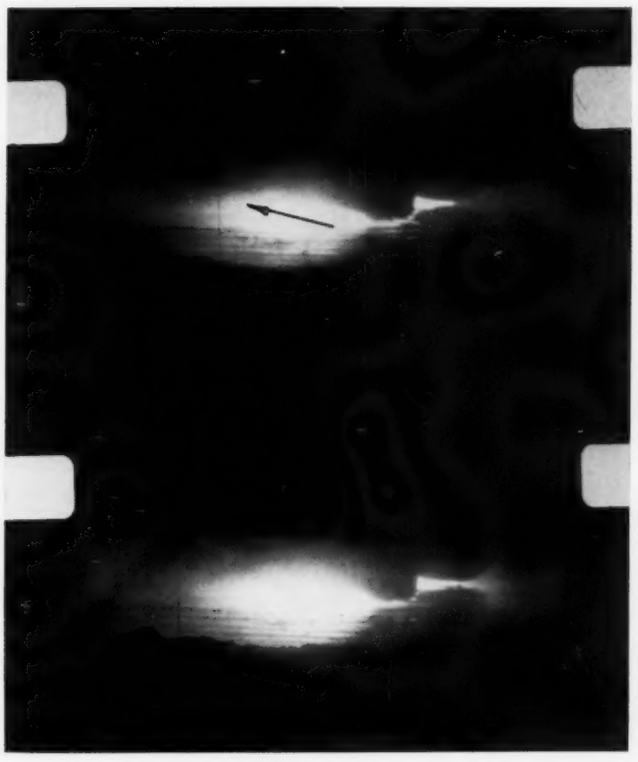


Figure 6 — This movie sequence depicts energy, radiated in the direction of the arrow, to the hot spot.



radiant energy. In each case, however, the electrode tip configuration appears to be the controlling factor in directing this destructive energy toward the hot spot area. For example, in the case of gas, dust and volatile vapor attack compare the relationship between the hot spot location, the electrode tip configuration, Figure 3 and the brilliant stream flow toward the hot spot area, Figure 4. Note that the attack stream originates in the arc zone and is directed into the hot spot area by the electrode tip configuration. Figure 5 illustrates a similar comparison that can be made for small high-velocity molten particles.

The radiant energy attacks occurred in the same manner, but at a more rapid rate. In many cases, the radiant energy stream appeared to flash the sidewall at the same frequency as the arc voltage supply (60 cps) and appeared most intense during the positive half cycle. Figure 6 illustrates a radiant energy flash directed into a hot spot.

Thus far it has been illustrated how the experience of the furnace crews and maintenance personnel was combined with normal and high-speed photography to determine the physical conditions capable of causing refractory damage in hot spot areas. The common origin of each condition was defined to be the arc zone, while the electrode tip configuration supplied the means of focusing each condition into a hot spot area.

A puzzling feature of these studies, revealed by supplementary photographic investigation of the interior of the furnace, was that even though similar conditions existed at all three arcs, corresponding hot spots did not necessarily occur. The relatively short duration of each film made it impossible to determine whether the over-all intensity or frequency of occurrence of each condition was the same in each area. The accelerated rate of refractory destruction in the hot spot area, on the other hand, established that either the intensity or frequency of attack, or a combination of both, was of greater magnitude in the arcs adjacent to a hot spot.

At this point in the investigation, the two basic problems requiring solution were: (1) to determine what phenomena caused certain arcs to generate hot spots, and (2) to devise an economical method of controlling these destructive phenomena.

The extreme scarcity of pertinent factual and fundamental data on the electrical and physical behavior of high current melting arcs along with the impracticability of running a controlled experimental test on a production furnace made it impossible to further explore the arc phenomena. Therefore, it was proposed to attempt to minimize hot spot effects by dispersing the destructive conditions over a wider lining area. First consideration was given to changing the electrode tip configuration in such a manner as to cause wide dis-

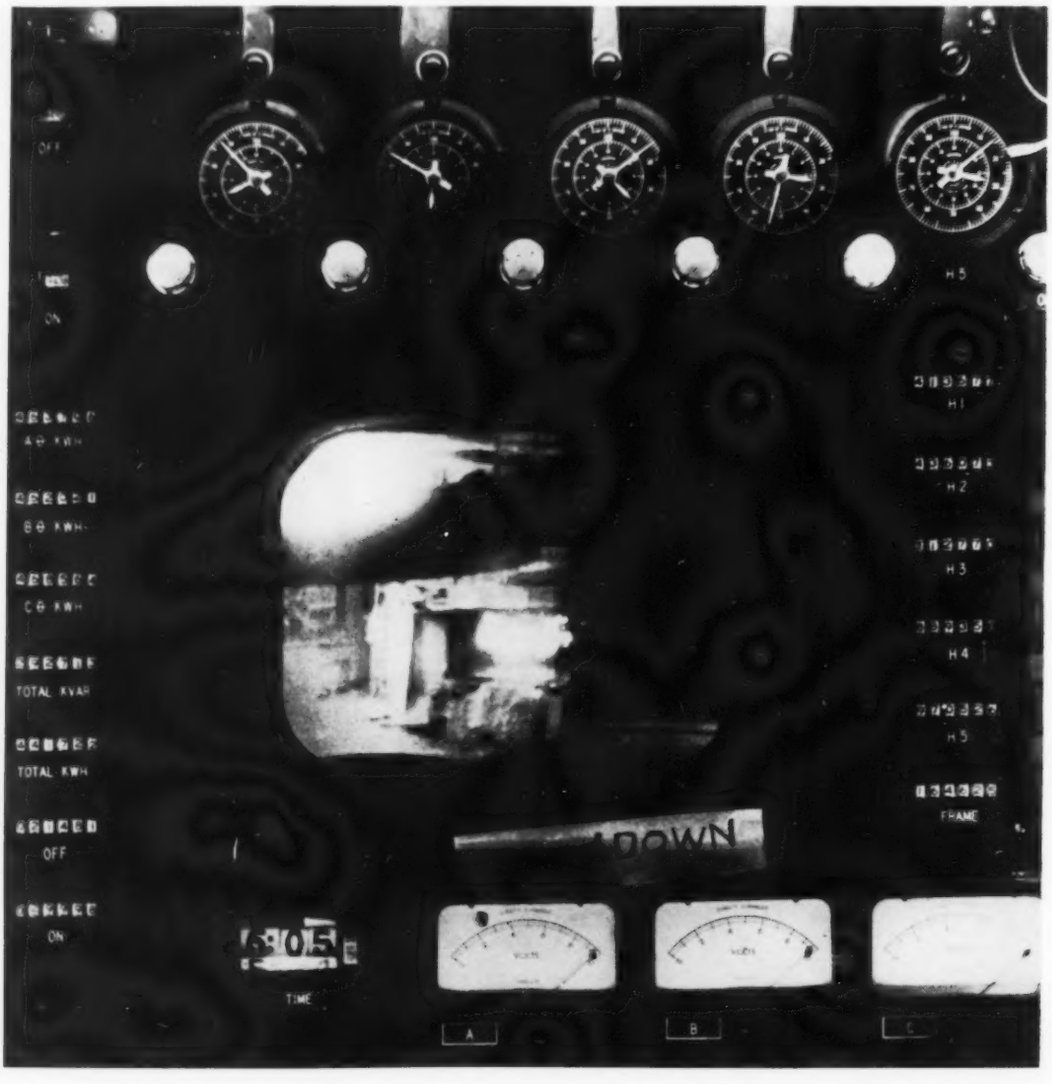


Figure 7 — This mobile laboratory instrumentation was used to get mechanical and electrical furnace data using both hollow and solid electrodes.

persion of the destructive forces.

Many approaches were suggested toward achieving this goal. Each approach was examined for its economical aspects and the permanence with which its effects could be retained. The two approaches chosen for field testing were: (1) modified transformer loading in terms of voltage and current adjustment as well as modification of the melting practice that determines the extent and sequence of use of each particular voltage tap; and, (2) inert gas injection through hollow electrodes.

Using the instrumentation normally supplied on an arc furnace, no noticeable changes in either the intensity or location of the hot spot were observed over the range of voltage and current adjustments necessary to retain furnace productivity. In certain cases where voltages were reduced and current values were increased to the ultimate safe load limit of the transformer, the electrode tip immediately assumed the flat configuration necessary for wide dispersing of the destructive forces of the arc. Unfortunately, these current values were too high for safe use with the existing secondary bus cables and electrodes.

Modification of the furnace melting practice within the limits necessary to maintain the desired production rate has no significant effect on the severity or location of the hot spots.

Inert gas injection through hollow electrodes was next explored as a corrective medium. Information derived from the use of this technique in inert gas welding applications, and from previous laboratory and field tests by one electrode supplier, indicated that some of the desired benefits of electrode tip configuration control might be achieved with inert gas injection with only slightly lesser benefits being gained solely from the use of hollow electrodes.[1]* The general theory of hollow electrode operation is covered in a previous AISE paper.

A decision was made to production test hollow electrodes because the use involved no changes to the furnace structure or operating practice. Inert gas injection tests were delayed pending the completion of the hollow electrode test.

A short test run of seventy-two 20-in. graphite electrodes of varying bore diameter was conducted on a 20,000-kva, 70-ton, top-charge furnace. As a result of this test, a one-in. bore diameter centered on the vertical operating axis was chosen as the desired specification for a full scale test of hollow electrodes.

The full scale test was designed to include the illustration of mobile laboratory equipment of the type shown in Figure 7. This equipment accumulated long term data on the electrical and mechanical behavior of the furnace while using both hollow and solid electrodes.

Prior to the start of the test, the alinement and location of the individual electrodes was checked and found to be proper. Also, the transformer loading on the two highest voltage taps was adjusted to the most efficient levels possible within the rated capacity of the transformer and retained there via automatic control with the tap changer switch. These checks insured that each of the arcs was operating in its proper

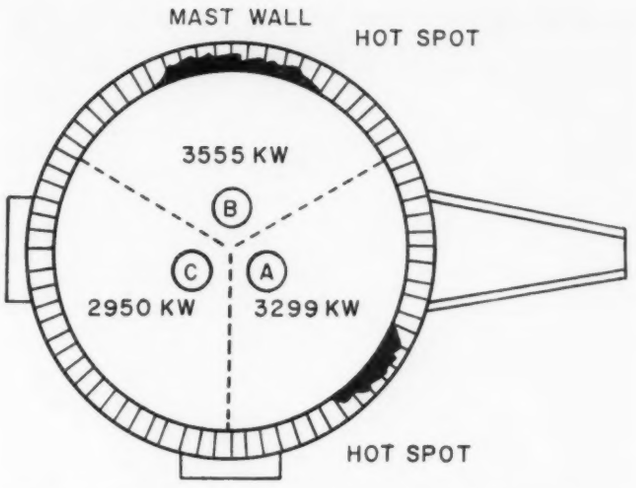


Figure 8 — Illustrated is the relationship of arc power level to hot spot location.

location and at the recommended optimum power level.

The actual testing of hollow electrodes started in conjunction with the installation of a new furnace lining. The test site was a 20,000-kva, top charge furnace with a rated capacity of 70 tons. The furnace products were common grades of steel using a single slag practice.

After 45 heats had been produced with the use of hollow electrodes, the lining exhibited the same hot spots as had been previously observed on this furnace and extensive patching was required. After the patching was completed, the test was resumed but all of the data accumulated thus far was subjected to a detailed analysis.

A noticeable characteristic of the data analyzed was the fact that the electric arc operating adjacent to each hot spot location exhibited a much higher average power level than the arc located in an area where no hot spot existed. Figure 8 illustrates the relationship between arc power levels and hot spot locations on an intermediate voltage tap.

Visual observations of the interior of the furnace during melt-down of the cold scrap charges revealed that the scrap melted more rapidly in the hot spot areas, thus exposing the refractory lining in these areas to the full destructive power of the forces previously described during the time that the scrap in the other areas of the furnace was being melted.

This data provided the first bit of conclusive evidence pointing directly at the electric arcs as the fundamental cause of refractory lining hot spots.

Immediate steps were taken to correct the difference in arc power level by adjustment of the electrode regulator control circuits. Considerable manipulation of both the voltage and current sensing circuits was required to acquire even an approximate balanced condition. A lack of fine adjustment provisions in the control components was the main obstacle encountered in making these adjustments and is suspected to be the basic cause of improper control operation.

The test observations continued after completion of the electrode regulator adjustments, and at the end of three complete lining campaigns the following results were reported from the combined use of hollow

* Numbers in parentheses refer to Bibliography at end of paper.

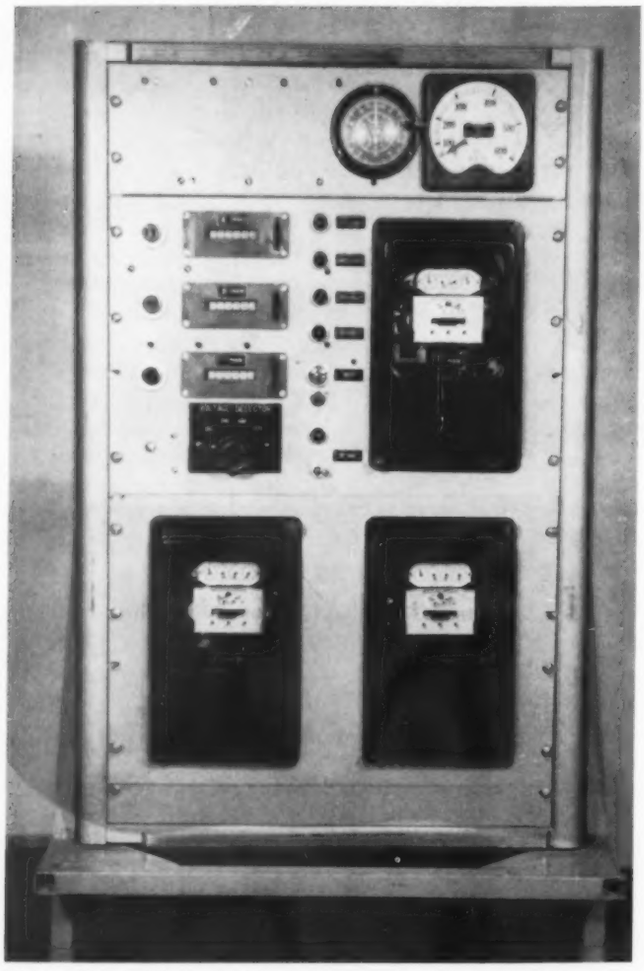


Figure 9 — This portable instrumentation is used to balance arc power levels.

electrodes and balanced arc power levels:

1. A 12 per cent reduction in the consumption of refractory material used for sidewall lining replacement.
2. A 9 per cent reduction in the consumption of refractory material used for roof or dome replacement.
3. Hot spot severity decreased to a point where no shutdowns were required between relines.

Since these results included the use of both hollow electrodes and arc power level balancing, it was difficult to evaluate the benefits derived from each. To clarify this situation, the laboratory instrumentation used for adjusting this furnace was assembled in the simplified form shown in Figure 9 and installed on another furnace experiencing hot spot difficulties.

Prior to adjustment, the furnace exhibited almost identical arc power level unbalances in the hot spot location as appeared in the test furnace. The same adjustment procedures were followed, and the same adjustment difficulties were encountered. Two lining campaigns have been completed up to the date of this paper and the results are as follows:

1. Hot spot severity immediately decreased. No shutdowns were required during each campaign for brick work patches in hot spot areas. No data was available as of September, 1958, on the actual rates of brick consumption per ton.
2. Electrode breakage during high power melt-down periods was reduced to an insignificant level. Previously, it was a cause of considerable delay time.

These results clearly indicated the effectiveness with which the arc power level balancing technique can help solve the hot spot problem.

The application of this technique to other arc furnaces will be relatively simple and inexpensive. In most cases, it involves only the procurement and installation of three accurately calibrated meters for measuring the average arc power levels. The exact balancing procedure may vary from furnace to furnace depending upon the control circuitry of different types of electrode regulators. Likewise, the capability of each individual regulator to retain proper adjustment will determine the frequency with which this preventive maintenance technique must be repeated.

Far more development work is needed to gather the basic knowledge necessary to promote more efficient use of the electric arc. In a broad sense, users of arc furnaces have more or less accepted the electric arc as a peculiar creature, and have done little to control its behavior or to ascertain its significance to many other furnace operating problems. For the future, we can look toward the electric arc as an inexhaustible source of new methods to melt and refine steel—but only after better ways to control it are found.

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Discussion

PRESENTED BY

H. E. BOOTH, Chief Electrician, Copperweld Steel Co. Warren, Ohio

J. A. BROSOVIC, Electromechanical Research Center, Republic Steel Corp., Cleveland, Ohio

E. J. BORREBACH, Application Engineer, Industrial Engineering Dept., Westinghouse Electric Corp., East Pittsburgh, Pa.

W. E. SCHWABE, Product and Process Development Laboratory, National Carbon Co., Div. of Union Carbide Corp., Niagara Falls, N. Y.

C. W. VOKAC, Manager, Electric Furnace Div., Whiting Corp., Harvey, Ill.

H. E. Booth: Shorter arcs on a furnace are a problem because, as you stated, you are limited on the current capacity of your secondary bus cables. I believe you said this furnace was equipped with a 20,000-kva transformer.

J. A. Brosovic: Yes, the transformer capacity is 20,000 kva with 20-in. electrodes.

H. E. Booth: What were the voltage settings of the furnace?

J. A. Brosovic: The transformer terminal voltages available were 365, 330, 270, 240 and 130 volts.

H. E. Booth: As a result of these tests did you maintain the same tap voltages?

J. A. Brosovic: Yes. No attempt was made to change any of the voltages on the particular furnace discussed in this paper. However, on some of our newer furnaces there has been a trend to reduce the voltage in some special cases where large amounts of heavy mill scrap are included in the charge.

H. E. Booth: Sometimes we are getting into higher arc voltage and, unless we use some kind of scrap material that will baffle the arc away from the wall, we probably will be faced with the same problem.

J. A. Brosovic: We have found this problem to be inherent in all furnaces of conventional design. In some cases, however, the severity of hot spots may be of a lesser degree dependent upon the charging and melting practice.

H. E. Booth: In regard to the current used in the various steps, were you using your highest current with your highest tap voltages on your transformer? Are you limiting the current so that you will not exceed the actual rating of the transformer?

J. A. Brosovic: The highest currents were carried on the highest voltage taps and did not exceed the rated capacity of the transformer.

H. E. Booth: How about the second and third taps, were they proportionately lower?

J. A. Brosovic: The second voltage tap was lower in voltage and arc power level but retained approximately the same arc current. The third voltage tap operated at a lower voltage, current and power level.

H. E. Booth: Did you notice a difference in the arc and the gases on your lower taps from that on the highest voltage tap? On the second highest tap and the third highest tap, as you obtained your shorter arc to your electrode, did it seem to result in a flatter arc or did it still go over to the side?

J. A. Brosovic: The arc length and the amount of gas emitted from the arc zone decreased as the arc voltage and arc power level decreased. The arc deflection toward the side walls decreased as the arc voltage and current were decreased on the second and third voltage taps.

H. E. Booth: With what size of transformer and what size shell diameter was this test conducted?

J. A. Brosovic: The shell diameter was 20 ft, and the transformer capacity was 20,000 kva.

H. E. Booth: The reason I asked that question was because we have experienced the same difficulty on the 18-ft furnaces. I was leading up to the question as to whether with the larger shell diameter, you still have the hot spots on a 20-ft shell.

J. A. Brosovic: Yes. Hot spots have been observed on furnaces with shell diameters of 14, 18, 20, 22 and 24 ft with transformer capacities ranging from 5000 to 36,000 kva.

H. E. Booth: Did you maintain a 48-in. electrode circle on the 20-ft shell?

J. A. Brosovic: No. The electrode circle was 60 in. on the 20-ft furnace and 66 in. on the 22 and 24-ft furnaces.

E. J. Borrebach: You have discussed balancing out the three phases of a furnace so that each arc is drawing the same kilowatt load to prevent excess side wall refractory burning near one electrode. Is this adjustment carried out by changing arc current only or is the transformer voltage tap also changed?

J. A. Brosovic: The transformer terminal voltages were not changed. The arc current values were changed and, of course, produced changes in the arc voltages.

E. J. Borrebach: The point I wish to bring out is that in any 3-phase furnace there is some difficulty in trying to obtain equal kilowatt loading on each electrode. Some years ago, a paper[2] was written discussing the problems that arise in 3-phase, 3-electrode furnaces where the three electrodes are in line; the paper discusses how, with electrode current balanced, one electrode will carry the most power, the middle electrode will carry less power and the other end electrode will carry the least. This power unbalance comes from unequal impedances in each phase.

The same thing will apply in the usual 3-phase steelmaking furnace, even though the electrodes are located an equal distance from each other rather than in line there will still be an impedance unbalance that will cause one electrode to carry the most power and one electrode to carry the least power if the currents are balanced.

It would appear that the proper way of correcting for this inequality of power input for each electrode would be by equalizing the impedance in each phase. This can be done in many ways, by adjusting the built-in reactance of the transformer, the lengths of the flexible cables, the lengths of the copper run from the flexible cables to the electrode holder, or even by varying the length of the electrode beneath the holder.

By any of these means, equal power input is obtained in each phase and equal arc lengths are also obtained.

However, if one electrode is operating at an excessive power input and equalization is attempted by a reduction in arc current of that electrode, the arc length is increased and even more burning of the side walls may result. Thus, by trying to cut back on power to keep the side walls from burning, the arc length of the guilty electrode is increased and even more trouble at the side walls may result[2].

J. A. Brosovic: Differences in the self inductance and mutual inductance of the components of the furnace secondary circuit contribute to causing unequal arc voltages and unequal arc power levels. These characteristics are inherent with conventional furnace design.

Adjusting the length of the center phase bus cable has been tried on one furnace and was found to indicate a reduction in the severity of the mast wall hot spot. Unfortunately, this technique can be applied only to furnaces having sufficient mechanical clearance. Shortening the flexible cables, in most cases, interferes with tilting the furnaces while increasing the cable lengths imposes a critical insulation and safety problem. Adjusting the lengths of the rigid copper bus tubes has not been considered because it would require a major revision of either the flexible bus cable terminal assembly or the roof ports.

Varying the electrode length beneath the holder offers an ideal method of increasing secondary circuit impedance in hot spot circuits, but is usually frowned on by furnace operators because of increased electrode breakage and oxidation. Increased electrode length

also imposes difficulty in removing the roof during top charging operations, and conversely decreased electrode length impedes the arc from reaching the bottom of cold scrap charges during initial meltdown periods.

It is true that equalization of the arc power levels by reducing the arc current of a hot spot arc results in increased arc length, but the increase in arc lengths discussed in this paper are minor. On the other hand, the electromagnetic forces that deflect the arc toward the hot spot areas decrease approximately by the square of the current. In this manner, even small decreases of the arc current can yield substantial improvement in refractory life in hot spot areas.

W. E. Schwabe: The question of refractory damage in electric steel furnaces is undoubtedly one of greatest importance to the economics of operation. In the course of our work on electric furnace research, we made similar observations as to the number and location of hot spots. The largest hot spot occurs mostly at the mast wall nearest to the center electrode, and a second hot spot can often be found near one of the two other electrodes. Furthermore, we are in agreement with the deduction that arc power in each phase is the governing factor of refractory damage. The author has clearly demonstrated that hot spot formation can be reduced by influencing the power input to each arc.

Arc power, measured in kilowatts, consists of the product of arc amperes and arc voltage existing between electrode tip and melt-surface. (Not all of this voltage, which could be measured by means of a voltmeter, connected by probes to these two points is effective in producing kilowatts but rather a percentage varying between 70 and 95 per cent.)

In essence, arc power is radiated power, and as long as the arc is surrounded by scrap, the power is absorbed by the charge, and the charge can absorb the impact and vapor effects so well demonstrated by the author in Figures 3, 4, 5, 6 and 7.

This situation, however, changes when the scrap gradually assumes the liquid state. The arc shielding effect vanishes, and after a flat bath is reached, the furnace refractory is at the receiving end of radiation and impact effects.

The formation of a hot spot is a direct result of the radiated power and its duration. In addition, the shape and geometry of the source of radiation, namely, the arc, influences the concentration of heat in the refractory. Therefore, arc length, and arc position are main factors. Arc length is almost identical with arc voltage, that is, a high tap voltage arc yields a long arc and vice versa. The arc being a rather flexible conductor, is subjected to mechanical forces originating in the arc and in the surrounding magnetic field. The vertical component of the force causes a depression of the melt, whereas the horizontal component deflects the arc stream toward the refractory.

High currents accentuate "arc flare," that is, they enlarge the horizontal component. A jet of metal vapors and solid globules is then forced from the arc spot on the melt toward the refractory where condensation and errosion take place[1][3].

Refractory damage occurs if a critical temperature on the inner surface of the refractory is exceeded, and it is likely that the errosive effects of vapors

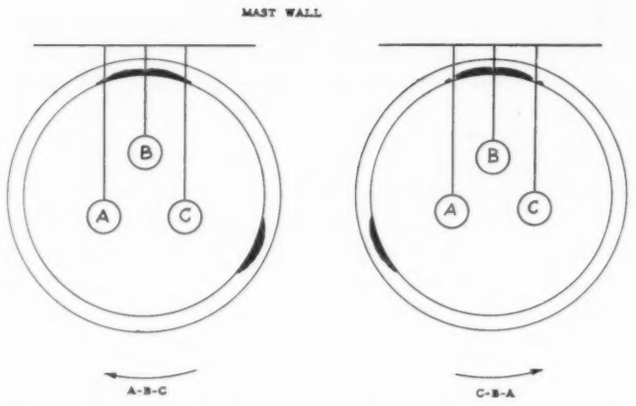


Figure 10 — A mathematical analysis shows that in an unbalanced 3-phase system such as the electric arc furnace of this type, the electrically-leading phase A releases less power in the arc than its counterpart C, the center phase B, not being affected.

and impact are stronger above this critical temperature than below.

One contributing factor is localized hot spot formation, and probably the most important one, is the electrical unbalance of the power system. Normally, the current path between transformer terminals and arc tips is shortest in the center phase, resulting in a lower impedance than in the two other phases. In addition, the coefficients of mutual inductance between the two outer phases are smaller than between outer and center phase because of the side-by-side arrangement of these conductors. If they were spaced on the corners of an equilateral triangle, the phases would be balanced, and the arc power at identical currents would be equal in all three arcs.

By way of mathematical analysis, Figure 10, it can be shown that in an unbalanced 3-phase system of this type the electrically leading phase A releases less power in the arc than its counterpart C, the center phase B, not being affected. The latter, due to the shorter current path, is more powerful than C. Figure 1 confirms this concept.

Perfect electrical balance cannot be accomplished by individual adjustment of the electrode regulator in each phase. Equal arc power in the three phases can be approached by reducing the power level of the higher powered phases B and C.

It is interesting that the electrical phase sequence at the electrodes determines the location of one hot spot of the outer phases: If the phase sequence is A-B-C, this hot spot is near C-phase electrode, and in the case of C-B-A phase sequence, the hot spot is near A-phase electrode (see attached diagram), B-phase hot spot remaining unaffected.

Furnace power characteristics depicting arc power, arc voltage and power factor of each phase have proved to be valuable in judging existing conditions or to predict the effect of any change.

As far as hollow electrodes are concerned, we have observed that arc flaring is reduced by the arc focusing influence of the hollow tip. Therefore, it is likely that radiation and impact of particles on the refractory are lessened. Because of the interaction of the many variables during furnace operation, it is difficult to examine each factor separately. Only systematic work such as presented in this paper can clear the way for

better furnace operation.

C. W. Vokac: I am inclined to discount the author's first enumerated point concerning the occurrence of hot spots, that is, impact loads during top charging being even contributory to the problem. I am rather inclined to give full credence to his second point—exposure of the hot spot area to attack by heat and particles shot at it. The particles are mostly iron oxidized in their trajectory as evidenced by the sparkler effect. The resultant iron oxide, a universal solvent, is driven into the refractory material where, with the aid of the heat, the two form an eutectoid of lower fusion temperature. This runs down creating the illusion that the refractory is melting out when, in fact, it is fusing out to form the depression.

To be sure, this occurs at each electrode and a depressed area would and does occur radially opposite each electrode. But the depth of the depression depends upon the rate at which the surface is bombarded by those particles and the rate of chemical activity occurring at the surface promoted by the heat blasting upon it. When these factors are not the same at each electrode, or when their product is not the same, the depressions will not be alike and the deepest will be recognized as *the* hot spot.

Just as every chain has a weak link, every furnace has a hot spot. But, the hot spot in a furnace can be moved about so that its effects may be distributed more evenly around the refractory periphery. The author points this out in his paper. I would like to elaborate further upon the effects and the causes.

That side of the furnace shell nearest the transformer room is the roughest spot for a hot spot to develop. Obstructions, etc., here, interfere with the natural flow of ambient air at that portion of the shell. The configuration of the electrodes puts the electrode most favored electrically also closest to the rough spot.

The electrode arm configuration in Figure 1 is commonly called "one short and two long." The center phase by virtue of its position is already favored by a lesser reactive voltage (IX) drop. The outer phases in their positions are handicapped by greater voltage (IX and IR) drops. The configuration in Figure 1 also puts the shortest arm (with the least IR drop) in the center and opposite the roughest spot. Still further, the furnace is regulated to the same arc current on all three phases. The results from all this are: (1) a higher arc voltage in the center phase; (2) more and greater mobility of the particles bombarding the hot spot in the rough spot; (3) more heat on the hot spot; and (4) increased chemical reactivity at the hot spot to further accelerate the erosion.

Reducing the current on the center phase would reduce the high kilowatt reading on this phase but it would also further increase the arc voltage on this phase. Increasing the current on this phase, would *reduce* the arc voltage but this would again increase the kilowatt reading on this phase—bringing us back to where we started in either case.

Putting a water-cooling jacket on the shell opposite the rough spot is often suggested as a remedy. But this is like putting a bandage over a malignancy. The malignant factors should be removed first. If the configuration is fixed and cannot be changed, then the reactance of the center phase should be increased. This can be done variously depending upon the particular equipment design.

We prefer the configuration using the "one long and two short" arms. This arrangement makes the center arm the longest and shortens the outer arms. Thus the total voltage drop of the center phase is increased and that of the outer phases is decreased as desired. Further refinement in circuit reactance balance among the three phases may be done by the operator paying particular attention to the relative positions of the arms. This is accomplished with proper electrode slipping. Of course, properly designed automatic electrode clamps are required for this.

The variance in the arc power levels, shown in Figure 8, are indicative of regulation from a signal heavily weighted by the arc current. This suggests the use of three single-phase wattmeters on the panel instead of the usual ammeters, and it suggests regulating with a properly balanced signal.

Electrode columns start with flat bottoms. The arc current has a tendency to seek the path, from electrode to electrode, of least obstruction. This would tend to form the arc at the tip of the electrode nearest to the center of the furnace bath. But the inductive effect of the other two arcs upon it tends to move it radially outward to the far side, so the arc is caused to disport off the bottom of the electrode between these extremes.

In 15 or 20 minutes the current arcs off a compromised position under the electrode which is a high spot on a cup-shaped surface, the lip plane of which forms an angle with bath. The inside of the cup is apt to open radially outward. Concurrently, the side of the electrode is attacked by the ambient oxygen causing it to "pencil" and form an angle with the vertical, the vertex being somewhere below the cup.

The pencil angle is a function of the electrode surface temperature and the concentration of the ambient oxygen. There seems to be a correlation also between the cup angle and the pencil angle—and these to electrode consumption. The author shows how this affects refractory deterioration.

The author reported also that a higher current reduced the apparent refractory erosion. A high current will increase the reactive voltage drop and decrease the arc voltage. This will improve arc stability and reduce the surging. The high current may also disintegrate the electrode tip at such a high rate that the electrode will be fed down faster than it can "pencil" or "cup." The reduced refractory erosion in this case would be obtained at the expense of more electrodes used.

The reduced arc voltage would result in a power loss too. The increased current would require larger conductors for sustained operation, as the author stated.

Substantial expansion of gases occur under each electrode. Between them the pressure is increased so that the gases flow instead radially outward. Since these are hot and ionized, the arc current will tend to follow them giving the impression of arc flare when the current surges.

Switching a furnace from a less efficient control, which caused or permitted such surging, to a more efficient control which eliminated the surging, also stopped the arc flare[4]. Many furnaces since have been equipped with this improved furnace control. ▲

INDUSTRIAL

TELEMETERING SYSTEMS

A sound engineering and economical choice of one of the many telemetering systems available requires consideration of future as well as present requirements and a careful study of ambient conditions and modes of transmission.

by Charles D. Close, President, cdc Control Services, Inc., Hatboro, Pa.

TELEMETERING is the transmission of meter information to a remote location. This is a specialized type of tele-communication. The telephone, television, telegraph are respectively the remote transmission of voice, picture and written word. All three are characteristically different in technique since the kind of information which must be transported remotely to obtain intelligent receipt of the conversation, sight or message places different emphasis on properties of the information.

It is known that the amount of information which must be transmitted in television is far greater than a radio broadcast. Television requires band widths many times the entire broadcast band. This same band handles over 100 separate broadcasts simultaneously. If it were desirable to broadcast a picture with much reduced definition and quality, ten channels of TV could be operated satisfactorily over the same band which one TV channel of high definition occupies. This illustration only covers the question of how many pieces of information must be transported per second.

Another question is, "How accurate must each piece of information be transported?" In the case of sound transportation, we have two systems of broadcast AM and FM. FM requires more band width than AM, but through its use more accurate information is transported. FM broadcast gives better quality (more accurate) and wider range in music reproduction than AM broadcasts. A third requirement for telemetering information is its "up-to-dateness." To illustrate, a wirephoto can utilize telephone lines for transmitting a photograph whereas special greater capacity, wider frequency range coaxial cable is needed to transmit moving pictures or action scenes. Obviously, if 15 minutes are allowed to transmit a photograph, a moving picture television broadcast which consists of 27,000 pictures every 15 minutes requires 27,000 times as much information channel capacity to send like picture fidelity.

In summary of terms, three basic decisions are needed to select telemetering direction:

1. Accuracy of information.
2. Promptness of information.
3. Quantity of information.

Telemetering systems differ from the above more common remote information systems in the nature of the information to be transmitted and the character format or use of received data. Where normal communication methods often ask as the ultimate, the receipt of an exact copy of material sent, i.e., a broadcast of a symphony when received should sound exactly as if one were in the tenth row center of the orchestra seats; the requirement for receipt of gas pressure at the

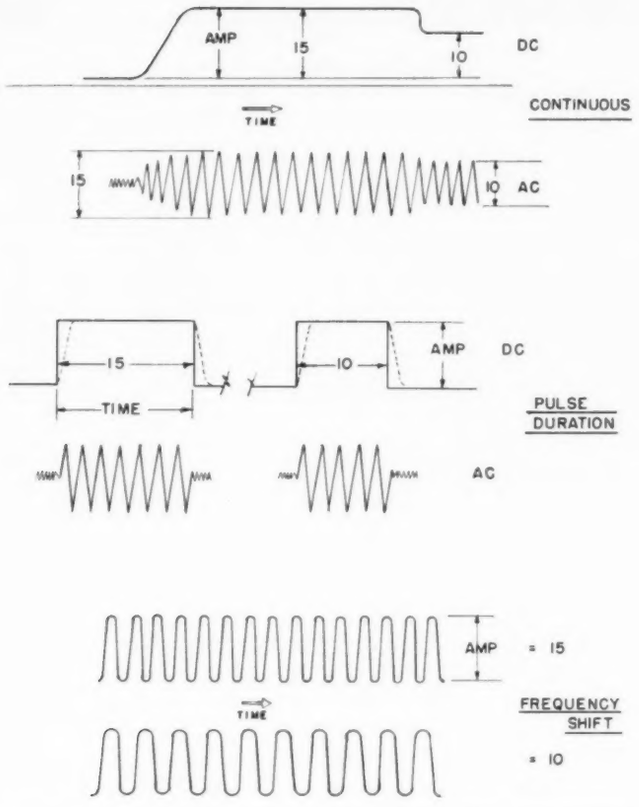


Figure 1 — Illustrated are analog methods of telemetering transmission systems.

load center should be presented as a timed history record allowing the operator to look at a graph of pressure plotted against time, or an alternate format of digital pressure reading on an hourly basis with off normal pressures typed in red and time of pressure fault or an alarm of abnormal conditions of pressure only. Now let us trace the difference in telemetering requirements for the three presentations discussed above.

First, consider the least amount of information would be transmitted if the receiving station only had to know if the pressure in the pipe line is abnormal. This will require one contact closure or the equivalent of one bit of information in one second of time to satisfy this; the capacity requirement is considered one bit per sec.

Second, consider the transportation of a continuous time record of pressure. If the accuracy of the transmission is assumed to be one per cent of range and the promptness of transmission is one second, the equivalent bits of information required per second is eight.

The third format could be digital or printed number with a pomptness of one second and an accuracy of 1 per cent. The number of bits required per second is eight.

The question immediately arises, if the same amount of information for analog or digital presentation can be had what is the big fuss about whether one should have analog or digital transmission, or analog or digital presentation of the information.

The limitation is in the economics and design consideration of available hardware. If what we want to accomplish is dropped for a moment, what is available to accomplish it with is discussed, a new breakdown of telemetry is had.

Telemetering systems consist of sensors, transmission link and received data center. Sensors are best discussed after discussing the influence of transmission link on the telemetering system.

Inspection of the transmission link breaks it down into a number of methods:

1. Analog or value assignment.
2. Position balance.
3. Force balance.
4. Frequency shift.
5. Code or digital.

The analog or value assignment depends on an electrical characteristic proportional to the transduced signal. In Figure 1 is illustrated an amplitude voltage which is proportional to the measured gas pressure. Any decay of accuracy of the original voltage amplitude is dependent on changes in line resistance, reactance, stray emf, inductance, etc. Such changes are variable on a seasonal and daily basis due to temperature and other ambient conditions. From experience such variations cause transmission to vary from $\frac{1}{2}$ to 6 per cent depending on line length and line environment. At best, accuracies are usually ± 1 per cent, and if improvement is desired, extreme care and individual treatment to compensate is required. Systems of transmission which fall into this category are d-c and a-c voltage amplitude, pulse time width, FM, etc. Pulse time width is an amplitude or analog type. Refer to the width of square waves, Figure 1, and notice that the rise time and decay time of beginning and end of the signal are not perfectly straight but decay at the rate dependent on the telemetering line characteristics. Any change in line characteristics will vary the slope of the beginning of the time pulse from the slope of the end of the timing pulse affecting the absolute value of the transmitted signal time by as much as two per cent under extreme conditions. Steel mill operations are severe on telemetered signals since extremes of temperature, magnetic field stays, voltage surges, etc., are more pronounced due to the variable load type of operation present at such installations. This is the opposite of the steady load and uniform temperature situations found in a refinery operation which may run for weeks under steady loads and temperature, conditions with the maximum variation being hourly, or on an 8-hour turn basis.

Some of the effects of transmission errors are further negated and increased accuracy of transmission is obtained through use of position and, more so, force balance system. The position balanced systems, or the selsyn synchros, rebalancing potentiometers, etc., are ruled out due to the high cost of multiplicity of sending and receiving units. No major reduction in cost is effected through transmission of many signals. This makes the equipment competitive for a few telemetered points but prohibitive if plant-wide telemetering is to be considered.

However, the current force balance systems must be singled out for special consideration because some economic mass-produced components used for other purposes are available and seem to fit into a unique position of consideration. Since one of the primary measurements is pressure, transducers or sensors designed on force-balanced principle transmit current

linear to line pressure. Within limits, any change in line resistance or reactance changes the position of balance causing the balanced sensor to correct for system resistance and send out necessary corrective voltage to maintain current flow in line corresponding to the pressure at telemetered sensor. Accordingly, envision a simple telemetering system consisting of a series of force balance current transmitters located throughout a plant at points to be transduced and an appropriate network of gathering wires to the central telemetered point. Since the receiving resistance voltage drop at central point is proportional to transduced pressure, intelligence of remote process has been telemetered to a central point through the use of conventional available industrial transmitters of an off-the-shelf variety. The evaluation of such a solution is now in process. Since the steel mill project may include distance up to five miles within the plant, part of such an evaluation includes a remote force balance pressure transmitter, a 19-gage, 2-wire transmission line three miles long installed in a conduit separate but adjacent to power conduits normally encountered in any electrical network as encountered in a steel mill. Manufacturers of such transducers have had little experience with use of instruments in long transmission loops, in fact there is little information available on intensity of collapsing magnetic fields, stray currents from electrolytic or thermal effects, or other stray electrical characteristics in steel mills which would be required to determine long line effect on the accuracy of transmitted information. Caution on the part of the manufacturer of components indicates extensive tests should be made before embarking on an extensive telemetering program using this principle. One basic weakness of this approach is that all sensed measurements cannot be economically converted to a current-force balance. Secondly, a set of wires is needed for each telemetered signal.

A method of telemetry transmission which has gained wide acceptance in the past few years is the FM or frequency-shift transmission. The transducer or sensor voltage value is converted to a base carrier frequency and a shift in frequency, Figure 1, corresponds to a variation in sensor signal. To illustrate, assume the gas pressure range to be telemetered is 0 to 50 psig and the output from the electrical transmitter is 0 to 0.5 volts, the output from the FM transmitter into the telemetering line can be 5 to 30 cps. The FM receiver will convert the 5 to 30 cps input to 0 to 0.5 volts output at the load center. The frequency received is unaffected by line stays or resistance change. In fact, considerable attenuation of signal down to 30 db or three per cent of original value transmitted will not affect the accuracy of telemetered signal. Any loss in accuracy occurs in the conversion of the signal to and from frequency shift and is estimated as maximum one per cent by one of the leading manufacturers of such components. This equipment is recommended for reliable long life in industrial plant application and can be used to send a multitude of signals on one line as will be discussed under multiflexing. The basic weakness of this system is the cost per channel which continues in a straight line relationship.

A more detailed explanation of the difference between analog and digital transmission is in order to understand the digital approach. An analog signal is a measurement of a relative value of volts, amperes, time, pulse width, etc., which is proportional to, or a function of, the value being telemetered. For instance a pressure of 30 psi on a 0 to 60-psi pressure gage is telemetered as a voltage amplitude with a voltage range 0 to 1 volt, the transmitted voltage in this case would be ½ volt. If the signal is a pulse width in analog time as a 15-sec telemetering period, the pulse width time would be ½ of 15 sec or 7½ sec. If the system is a frequency shift system or frequency modulation system, such that the frequency equivalent to zero pressure is a frequency of 100 cps and the pressure corresponding to 60 psi is 120 cps, then frequency of 30 psi is 110 cps. In all three cases, there is proportionality between the measurement and the telemetered value. In order to improve accuracy in a proportional system, the least value must be measured more accurately. Analog measurements are historically one per cent devices at best.

TABLE I
Four-Place Binary Code Table

Decimal	Natural binary
0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001
10	1010
11	1011
12	1100
13	1101
14	1110
15	1111

By definition a digital system assigns a logical code to the signal. The code contains a series of values of signal strengths for transmitting one measurement of information. To illustrate, a binary digital code transmission assigns two levels of pulse (binary) to transport all information and by a sequential combination of pulses or through use of separate channels for each set, the value is transported, Table I.

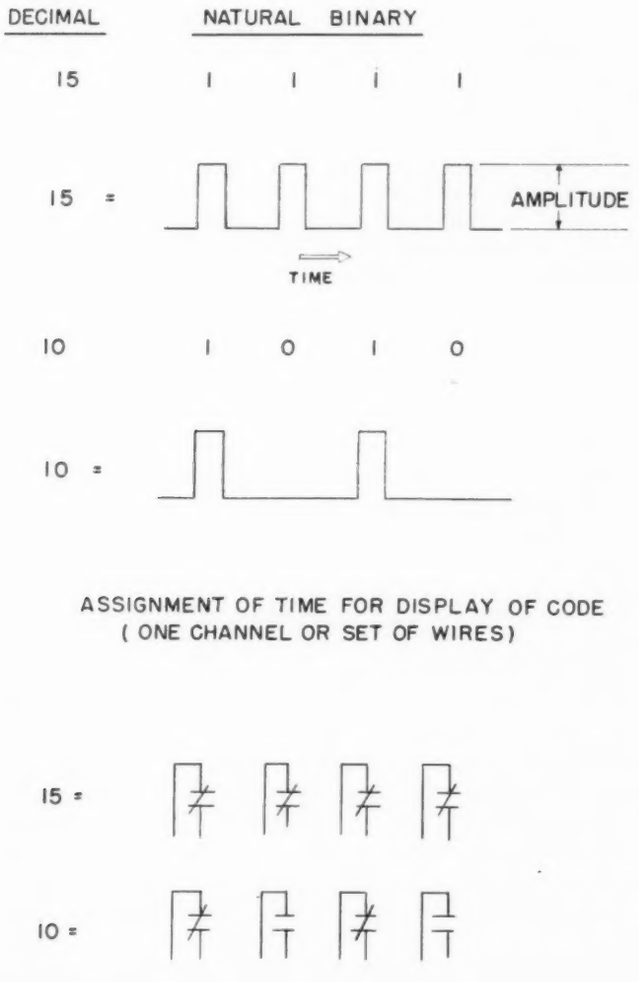
It can be seen from the above that if we desire to measure up to 100 and use natural binary notation, we would require use of eight pulse decisions or eight channels. The number or pulses of channels needed for transporting a value of 1000 to an accuracy of one part is 10 pulse decisions or 10 channels. Bear in mind that if the pulses are spread in the time dimension, this is called series transmission; if all pulses are simultaneously selected in the required number of channels, it is called parallel transmission. In either case, it is obvious that noise level of strays and extraneous electrical signals have no greater effect on the tenth pulse of the $\frac{1}{1000}$ place than it does on any other value. It is possible to transmit *any degree of accuracy* using digital techniques and the accuracy can be as reliably telemetered as the 2-place accuracy. It is commonplace to receive a telegram with numbers of any value and accuracy in the last place. This is possible because of digital transmission techniques.

How the system is related to its parts is shown in Figure 2.

Multiplexing is a method of expanding the use of the communication channel or wires without increasing the number of channels or wires used. There are two basic divisions of multiplexing.

Parallel multiplexing is simultaneous transmission of many signals over a single channel. The most common means is to send multi-frequency signals over a common channel; each frequency or carrier is set at a different frequency. All the frequencies are varied in amplitude or frequency by the respective sensors at the receiving end; each receiver is insensitive to all other frequencies except its receiving frequency through use of a filter to notch out all other frequencies. By this means 15 frequencies can be handled in one telephone circuit, spacing each carrier 200 cps apart at 100, 300, 500, up to 2900 cps. Either FM or AM tone equipment can be used to accomplish this. Due care must be taken to eliminate harmonic cross-talk. This is accomplished by judicious selection of frequencies. Parallel transmission can include use of additional channels in the form of more wire, or microwave carriers.

Figure 2 — There are two methods of transmitting digitally.



Series multiplexing takes many forms. Essentially it is time sharing of a single communication path. Some information does not change quickly such as the water or gas reservoirs pressure, or the level of the plant water supply stream. A look at any one of these every five minutes may be satisfactory. Accordingly, a switch to select one slow moving variable at a time, transmit, synchronize and receive the corresponding value once every cycle makes it possible to handle 100 such variables in a 5-min period using relay and stepping switch techniques. It is obvious that rotary synchronized mechanical switches operating at high speeds could step this frequency up and produce series muliplexed data at a sample rate of 100 points per second; however, such equipment has proved costly and short lived where used in military applications and the latest units are all electronic, eliminating switch contact wear problems. Such units will be available for industrial applications in modular construction as component standardization progresses. Another series multiplexing method permits bringing in any signal on demand by an appropriate code at each remote point. The load center may "dial in" any subscriber. This is similar to a telephone dialing system.

In many installations the collection of key plant measurements is invaluable, at least easy to justify for value gained by such key information centralization As the control center takes on more of the functions of plant operation, the cost to install additional equipment becomes more critical. Beyond the economies of equipment, a look at method of transporting such information must be evaluated.

COMMUNICATION LINK

There are a number of methods available to transport telemetered information in steel mills. A list of methods includes:

1. Direct wire.
2. Telegraph wire.
3. Telephone carrier.
4. Power line carrier.
5. Radio microwave.

In steel mill applications the direct wire method bears major consideration. Even though the number of points required in the initial installation are few, consideration should be given to the installation of a major multi-conductor cable between the main plant information gathering centers and the load center. The cost of installing one multi-conductor cable is only an increment greater than installing one set of wire and can afford future system flexibility if due consideration is given to the cable pairs required in future plus the shielding and wire size consideration. Accordingly, an investment in higher cost cable to obtain better protection against strays, and other cable faults is worth the effort of selection if this system of transportation is contemplated. Consideration should be given to cross-talk problems between wires and use of wire for frequencies up to 3000 cps with possibly one set of wire suitable for industrial television frequency transmission. This survey may indicate present plans can be adequately covered by direct wire with future bearing consideration of more sophisticated methods.

Present communication circuits already installed present a possible source of transmission link at zero investment. Certain limitations must be imposed on receiving and sending equipment with regard to energy level usable on such circuits. A telegraph-grade telephone line is quite inexpensive, less than $1.00 per mile per month if rented. However, it is quite limited as to what can be transmitted on it since frequency greater than 30 cps is intolerable. Accordingly in one continuous signal or a multiplexed signal one every two seconds, if 1-min receiving time is satisfactory, 30 transduced variables could be received. A class one voice grade telephone line can be used for carrying 15 continuous variables, or 3600 variables if multiplexed for maximum reading time of one per minute. A combination of these two extremes could easily satisfy most near-future industrial telemetering systems. Line rental cost would be $4.50 per mile per month. The use of part of the line for voice up to 2000 cps and the balance for telemetry is a compromise link making available up to 20 variables reset every two seconds plus 600 variables reset every minute. Although coaxial, video-grade telephone circuits for transportation of large masses of information are available between large cities, their use in steel mills seems remote for telemetering purposes.

Radio telemetry is overcrowded in most areas, and possible cross-talk concerns would generally rule it out.

Microwave transmission is a real consideration since it makes available a means of protecting the airborne signal by direct focus of information on a receiving parabola and eliminates inner plant communication problems and the smallest system installed furnishes 2000 continuous channels of information, each with 10-kc band width or three times the band width of a telephone line. The cost of such a system with four outlying stations and one central receiver would approximate $80,000. On a communication link basis, it would take use of over 1000 continuous channels to break even compared to other methods. However, this would eliminate time-sharing equipment and the cost of some telemetering multiplex equipment could be credited to the microwave installation. Any outlying areas up to 30 miles away could also be credited since identical installation costs would be required for 30 miles as for a few miles transmission distance.

Power line carriers are always available. The methods have been used for years; generally cost of equipment has curtailed use except for direct control of power and utility facilities as part of the electrical energy network.

The most promising systems are direct wire for modest numbers of telemetered signals and telephone-grade circuit for maximum number of signals. In general, microwaves cannot be considered except for very large numbers, over 1000 channels of continuous signals or for long distances probably 10 miles or more.

TRANSMISSION CARRIERS

All telephone circuitry requires carrier frequency for proper use of lines. Carrier frequency of the amplitude-modulation type, when used as a carrier for analog-varying signals, requires critical initial adjustment of gain to compensate for line loss. Any variation due to change in wire paths or resistance, changes the calibration of instruments. Accordingly, AM carriers require greater signal to noise ratio for maximum accuracy since distortion of AM tone is possible through line resistance change.

All FM tone equipment is practically insensitive to attenuation loss since it is possible to reamplify a signal of $\frac{1}{30}$ original strength without distorting the frequency. Frequency transmission can be expected to maintain accuracy of signal better than one per cent. The inherent weakness is in the frequency tone converter which is inherently a $\frac{1}{2}$ per cent error instrument in transmission and $\frac{1}{2}$ per cent error in receiving.

SENSOR

The conversion of the processing information into an electrical signal is a vital consideration in the telemetering link. If the information to be telemetered is visual, such as a mercury manometer bank of pressures and the requirement is visual central presentation, a television system would be best. Where normally the television is too redundant, in a few cases it is a natural.

Sensors for flow, pressure, temperature, etc., should be standardized for interchangeability and as little dependence given to present-installed operating plant transducers for telemetering systems. Wherever possible, power supply to remote transducers should be independent of local power to permit central control even during local electrical failure. Newer types of transducers are becoming available which answer some of these requirements. Care must be given in selection to keep noise-to-signal ratio low and signal strength high enough to prevent interferences from ambient conditions in the gathering center collecting lines. This has been a common fault requiring care in shielding and grounding of transducer leads. Good grouping of sensors can reduce number of pieces of retransmission equipment. Selection of a minimum number of known electrical signals can cut cost and make for more flexible systems. Computation of sensor information to obtain more general parameters should be done at sensor and where economy can be effective. This is one of the major cost factors in a system and should be given much care in selection as it is often the vital deciding component determining the entire approach.

All sensors but shaft rotation, frequency and counting are most easily transformed to analog signals. A digital signal has such excellent signal-to-noise ratio that no decay of accuracy is obtained once a digital code is established. Unfortunately, few digital sensors of note in pressure and temperature are available for field installation, and those available are high priced or unsuitable for minimum sensor groupings. Economic digital sensors could revolutionize the telemetering approach since there would be no question of analog digital telemetry; there would remain only the analog question of human engineering at the load center.

LOAD CONTROL CENTER

The first and most urgent need of plant telemetering is instantaneous central data gathering. With immediate recognition of vital in-flow and out-flow of power

requirements and energy storage in an integrated steel mill, electrical demand charges could be kept to a minimum by proper use of stored power in the form of fuel oil, gas in holders, steam in mains. Today's operations which require communication by telephone leave much to be desired when such severe penalties are imposed on a plant by outside power companies, for one slip occurring in a 15-min period of excessive outside electric power demand. Although this penalty is unique, in certain cases it is a below-the-normal steel mill operation which swings through extremes of power consumption in any 8-hr period because there is no central instantaneous load center monitoring and immediately correcting off peaks. However, gathering of data is only the beginning. Received data is best recorded in typed form, off-normal points are emphasized by red or other techniques. A continuous line, plotted against time, of critical values is a good operating guide, often able to give a system operator a feel of operation not obtained in any other form. Such key information as demand meters can be precomputed on a 1-min basis to alarm operator of possible abnormal 15-min demand while time is available to correct the situation.

Much of the data is in crude form undigestible except through computation; accordingly, the next step is usually computed parameters as operating guides. This can take two forms: digital computation for energy balances and analog computation for dynamic system planning.

Supervisory control of the remote points can be initially accomplished by telephone to the remote attended power centers. For more flexible and tighter control a limited number of energy storage valves can be directly controlled from the load center.

The ultimate is automatic feedback from load center with start up and shutdown of remote operating units from central points.

Since dependence on a load center would require maximum reliability of equipment, early consideration of digital transmission techniques would permit future expansion with higher reliability and lower cost. It is known that digital telemetry is high in base cost for the first few pieces of information but low cost for additional communication channels.

Central control of major industrial processes as complex as steel mills is in its inception stages. Suitable telemetering building blocks for a well conceived, long range plan are becoming available and should be considered in place of the small step, limited packaged approach.

Discussion

PRESENTED BY
E. B. TURNER, Industrial Engineering Section, General Electric Co. Schenectady, N. Y.

E. B. Turner: Telemetering has been defined by ASA Standard C-42-1941 30. 40. 150 as the indicating, recording or integrating of a quantity at a remote point by electrical translating means. There are many means of accomplishing this requirement within the two basic types, analog and digital.

At the present time analog telemetering is more widely used in the industrial area. Digital telemetering is becoming increasingly prominent in data center applications where visual scanning becomes inadequate. For example, an operator can detect a deviation or excessive rate-of-change only by continuous inspection. Digital techniques lend themselves to monitoring of instrument readings for these functions.

In digital telemetering as well as analog, the degree of common channel or equipment usage (multiplex) is determined by operating requirements. Continuous indication or record requires a continuous channel. Intermittent sampling is often permissible where the scanning cycle is short, for example, one or two seconds per reading. After determining the continuity requirements of various data, the form in which it can be used must be considered. Visual display in analog or digital form, type out, high-low alarm and tape storage are all possibilities.

Accuracy of the measuring system enters into the choice of telemeter equipment primarily where accuracies of better than ± 2 per cent are required. Most analog systems can operate within these limits over prolonged periods. Greater accuracy can usually be obtained only by the use of digital transmission, thus insuring that the accuracy is as good as the primary measuring system, since there is no inherent transmission inaccuracy.

After considering all these conditions, it is conceivable that some modification will be required by the specific physical problem. For example, the available connecting channel may require more multiplexing of telemetered information than is considered to be desirable. A metallic pair is usually available and adaptable to use either directly, with d-c pulsing or with frequency (audio tone) transmission.

In the industrial plant with a 5-mile radius, almost all types of connecting channels could conceivably be used. However, direct wire will undoubtedly prevail. For distances of this magnitude, a-c amplitude transmission is usually impractical. For these distances d-c transmission of various types is predominant or if simultaneous use of a common channel is required, audiotone equipment can be employed for multiplex purposes.

One consideration which may be present in some installations is the possible combination of supervisory control functions and telemetering. Telemeter codes of a binary type are similar to supervisory codes. This form of combined system appears particularly useful where groups of data are scattered over a plant area.

Telemetering and supervisory control offer the steel industry the opportunity for many economic advantages. The ability to centralize control and supervision of plant facilities, for example, has an immediate economic return in more efficient use of personnel. This centralization is the first basic step toward optimum utilization of plant facilities and energy sources. ▲

Figure 1 — The fire cracked surface of a lightly acid-etched piece cut from a steel slab mill roll is shown. Magnification is 4.15.

THE service life of iron and steel rolls is often limited by fire cracking, a rather wide-spread phenomena that usually makes its appearance on the surface of the roll body as a network of very fine cracks. These cracks gradually become more pronounced and grow deeper until eventually some of the roll surface may chip out. If the crack growth continues, the roll may break while in the mill.

Although fire cracking is a relatively common occurrence, there is much to be learned concerning exactly how and why it happens. Accordingly, to determine both the present state of knowledge and the theories of men familiar with the application of rolls, the literature of the past 25 years was reviewed to locate articles on fire cracking, and opinions of men familiar with rolling mills were solicited. Photographs illustrating fire crack patterns on iron and steel rolls were also solicited.

This paper summarizes the findings and theories concerning the causes of fire cracking and what has been done to control it. These will be discussed under four separate sections, namely:

1. Blooming mill and slabbing mill rolls.
2. Structural mill rolls.
3. Hot-strip mill work rolls.
4. Non ferrous mill work rolls.

Before considering each category, the writer emphasizes that the references discussed are based on mill observations, plant trials and conjectures, and should not be interpreted as final conclusions based on exhaustive study or research.

Regarding the first category, most of the information located during the present survey was on fire cracking in blooming mill and slabbing mill rolls. For these rolls Keller[1]* has an interesting theory about the origin of fire cracks. In describing the mechanism of fire cracking, he states that the heated surface layers which are under strong compression and unable to move tangentially or longitudinally, relieve their stress by elongating plastically in the radial direction. As a result these layers take a slight permanent set, so that an originally small cubic element becomes a rectangular prism having a height radially greater, and the width smaller in the other two directions than the sides of the original cube. When the surface layers are cooled, the adjacent inner layers prevent the surface layers from contracting axially or tangentially, and the tensile forces necessary to hold them stretched to their original length in these directions become greater than the tensile strength of the roll ma-

* Numbers in parentheses refer to Bibliography at end of paper.

Figure 2 — This fire cracked surface on a deeply acid-etched piece is from the same roll as Figure 1. The depth of the major crack is $\frac{5}{32}$ to $\frac{3}{16}$ in. and they are about 1 in. apart. Magnification is two.

FIRE CRACKING IN ROLLING MILL ROLLS

A summary of the theories of the causes of fire cracking and what may be done to control it.

by N. R. Arant, Technical Director,
Roll Manufacturers Institute, Pittsburgh, Pa.

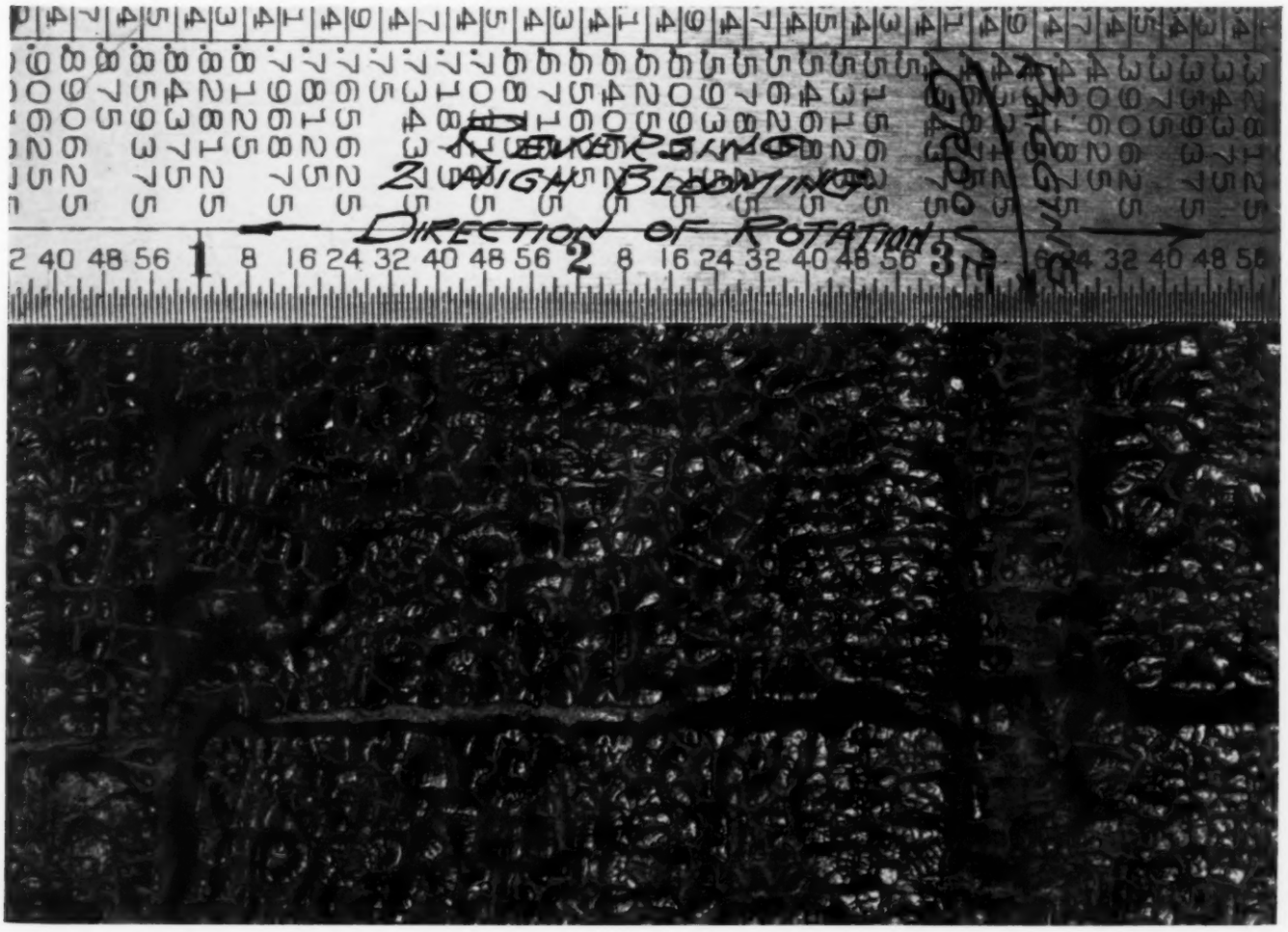
terial. So, the surface layers crack along the length and around the roll producing a crack pattern as shown in Figure 1, and penetrate at right angles to the roll surface as shown in Figure 2. It should be clearly understood that all of the illustrations presented in this paper represent unusually severe fire cracking, and that they are being used to emphasize specific types of patterns.

Hesse[2] has a more general theory of how fire cracks originate. He concluded from seeing rectangular-shaped cracked areas appearing during the first few passes on an alloy cast steel roll (65 Shore) used in a 3-high stand for rolling alloy steel that these cracks can be produced either by rapidly heating the surface and then air cooling, or by improperly dressing the roll. It is his opinion that the greatest thermal gradient occurs when the reduction per pass is the greatest—during the first few passes.

Moses (3) states that lack of care when block tooling alloy steel rolls can cause fire cracking and influence the patterns that develop. He gives examples of this occurring in a series of damaged 40 x 80-in. plain-bodied slabbing mill rolls. The spacing between the rows of circumferential fire cracks was found to generally coincide with the spacing of overlapping 12-in. wide tool cuts. According to him, grinding the bodies of new rolls eliminated the circumferential cracks, which obviously were caused by the slight differences in levels of overlapping block tools.

He also says that a characteristic of block-tooling alloy steel rolls is a relative surface roughness in one direction around the roll, which is in contrast to the satiny, smoothness in the opposite direction. With such machining tiny saw-toothed craters are produced which become stress raisers during service, and undoubtedly affect the extent and patterns of fire cracking.

Figure 3 — Depicted is a much worse-than-average case of fire cracking on a reversing 2-high steel blooming mill roll. It was caused by a series of "stitches" and was due to factors other than roll material. Magnification is two.



Moses gives an example of fire cracking of another type that causes breakage through the bodies of blooming and slabbing mill rolls. According to him, a newly fractured surface shows a blue crescent-shaped area with depths range from 3 to 9-in. or more toward the axis. He states that this type of fire crack is caused by "stickers"—partially rolled ingots remaining under pressure between stalled rolls. When the rolls are backed-off the ingot, the red-colored hot spots on the rolls are flooded with cooling water causing drastic localized chilling and a crack. A worse-than-average example is shown in Figure 3.

Blooming mill and slabbing mill rolls show a variety of fire crack patterns, with differences in progression and severity.

In a forged steel roll used in a slabbing mill, Hesse [2] shows large cracks running along the edges of a group of honeycomb-shaped cell areas. He concludes that the honeycomb and rectangular-shaped patterns occur first. The large circumferential crack pattern is formed later by bending stresses whereas the longitudinal cracks are formed by high-thermal stresses. Examples of these fire crack patterns are shown in Figure 4.

He also says high-thermal gradients produce mainly tangential tensile stresses. For example, in a 2-high stand of a heavy plate mill, most of the main cracks on work rolls were in a circumferential direction, which indicates the effect of thermal stresses plus bending stresses. An example of this kind of cracking is shown in Figure 5.

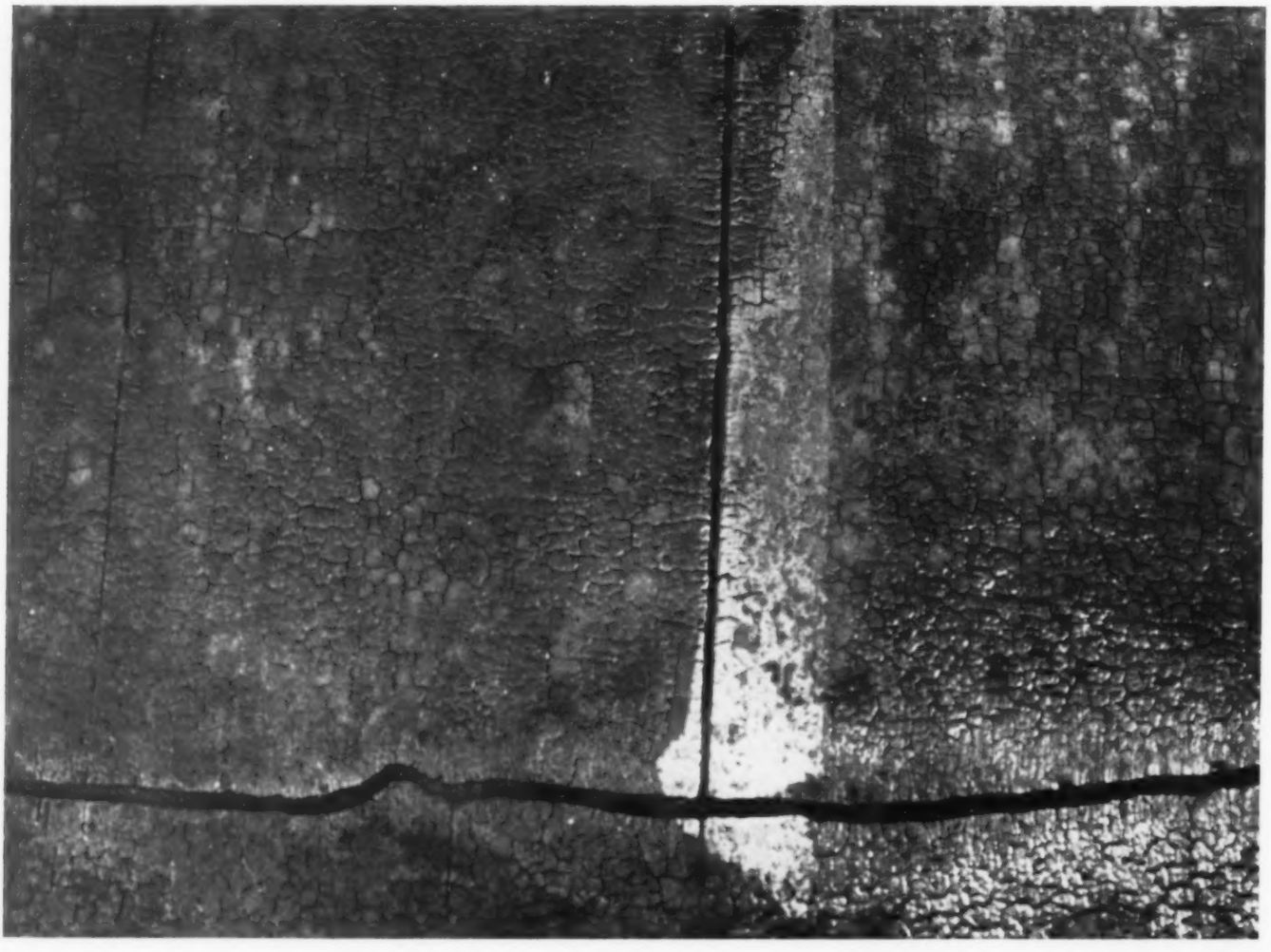
Crack growth and possibly roll fracture may proceed because of bending stresses. Hesse[2] says that the addition of bending stresses in 2-high stands may transform originally small crack patterns into larger circumferential cracked areas which are avoided because they lead to roll fracture. An example of this kind of cracking is shown in Figure 6.

Moses[3] says that the walls of severe circumferential cracks such as those initiated by "stickers" are worn smooth by a flexural movement caused by bending—crack growth continues inward toward the core until the unaffected areas cannot sustain the rolling load and the roll break. He also says that the action of steam extends the depth and width of a small crack at each revolution of the roll, which continues throughout the installation of the roll.

Again, there is a variety of opinion on the effect of fire cracking, and means of controlling it. Moses[3] says that it is generally desirable and necessary to develop a fine fire cracking pattern soon after new and redressed rolls are installed, particularly on production mills. Smoothly machined surfaces will not "bite" into the steel. Furthermore, he says unbroken ingot scale builds up in the roll gap, curbs the movement of the rolled metal and causes stalling and stickers.

In a trial of grinding instead of block-tooling new

Figure 4 — This steel blooming mill roll has a fine fire cracking pattern ($\frac{1}{16}$ to $\frac{3}{16}$ in.), a large longitudinal crack, and smaller circumferential cracks. The severe cracking appears to have been caused by a "sticker" sometime during the service life of the roll. Magnification is one.



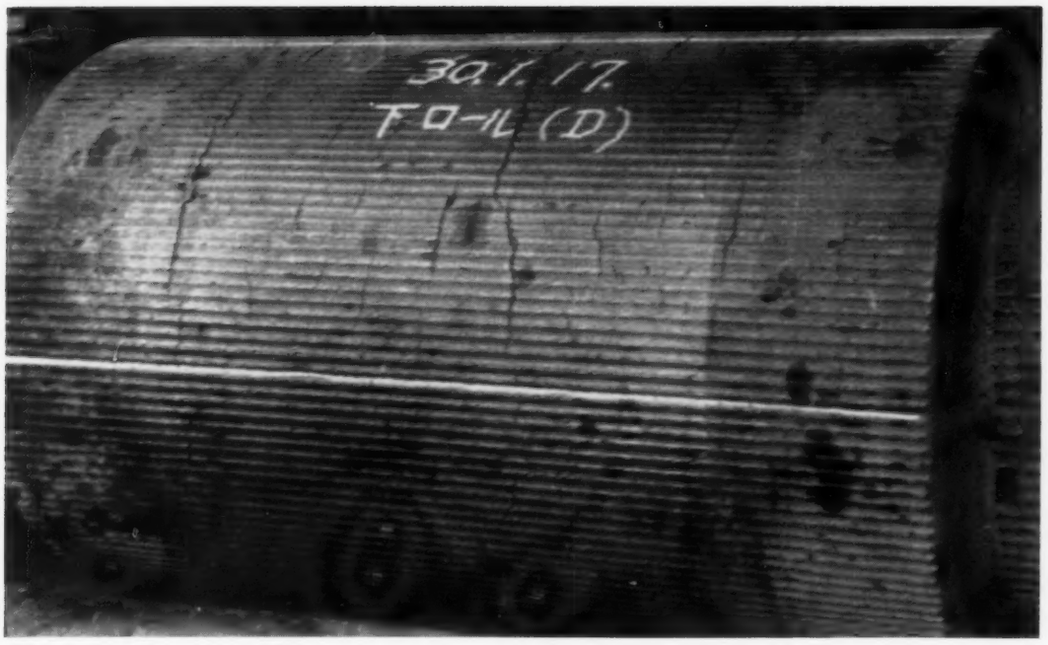


Figure 5 — Apparently caused by a combination of bending and thermal stresses are these large circumferential cracks in a 43-in. steel blooming mill roll with ragging. This illustration is reduced by a factor of 13.8.

alloy steel rolls for a 40 x 80-in. slabbing mill, Moses reports a definite reduction in the depth, cell-pattern size and spacing of the fire cracking as compared with the usual severe alligator-hide patterns. However, the smooth finish caused slipping—several mill operating turns being required to develop a satisfactory surface roughness.

Hesse[2] says that in roughing mills with water cooling, fine fire cracks on the roll surface were not detrimental to the piece being rolled. However, there are some instances in which the deep honeycomb-shaped pattern in roughing rolls can cause hairline cracks on the rolled product.

Scott[5] in his paper on cast rollmaking states that where roll life is limited by fire cracking resulting from thermal fatigue in combination with cyclic stress, a steel having small grain size would be selected which would be heat-treated to its most stable condition (for example, spheroidized). The required hardness would be developed with alloys.

Allison and Peterson[6] in their paper on the manufacture and use of cast rolls say that the blooming mill rollmakers' art lies in balancing chemical composition and heat treatment in a narrow range to produce maximum strength and fire cracking resistance.

According to Hesse[2], up to about 940 F roll-surface

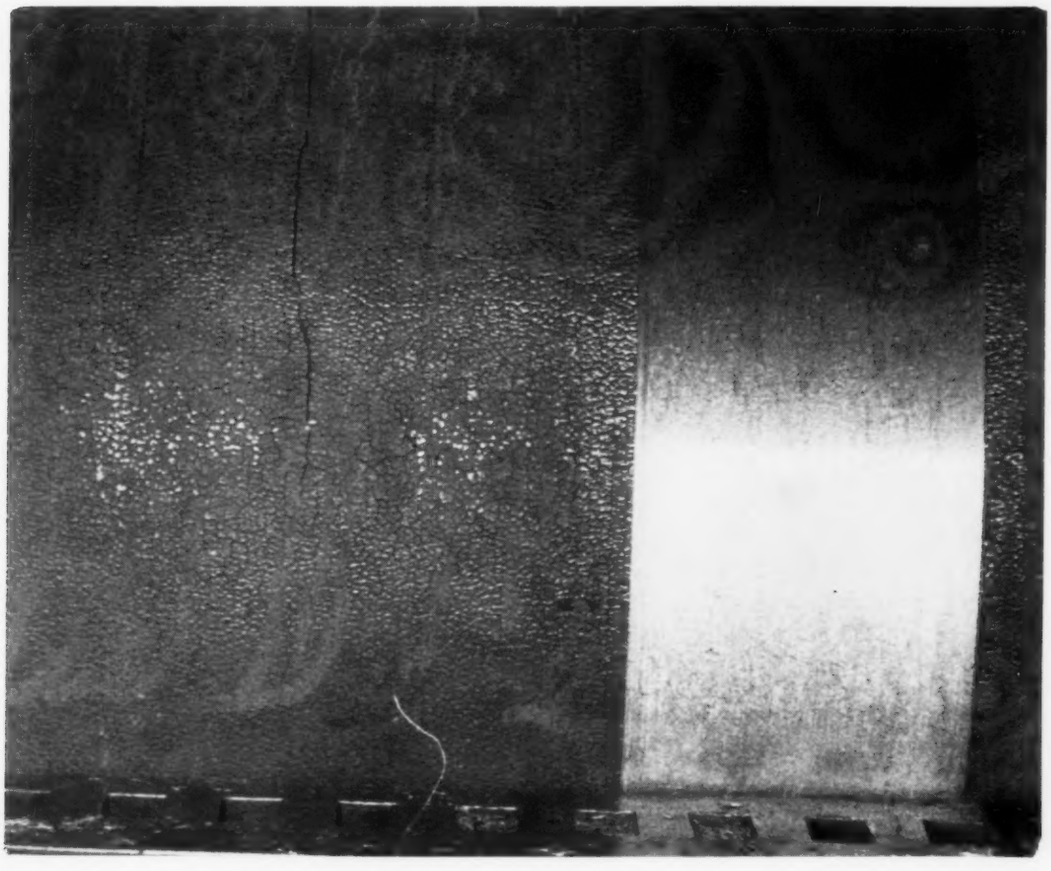


Figure 6 — This 45-in. steel slab mill roll has a fire crack pattern and large circumferential cracks. It appears to have been subjected to a sticker sometime during its service life.

temperature (in the roll gap), chilled iron rolls are preferred to grain-type rolls and are much better than steel rolls of the same hardness since there is less danger of crack formation. This is because chilled iron rolls have a higher compressive yield point than steel. However, if the heat transfer is so great that either iron or steel rolls become plastic at the surface, steel rolls are preferable because of their higher hot strength. The danger of increasing the crack size because of the notch effect is naturally greater in brittle materials.

In six blooming mills Hesse found that the fire crack resistance of alloyed rolls is superior to chill-type and grain-type rolls. He says that alloyed steel rolls whose composition and heat treatment had been selected to increase their heat resistance gave the best results. However, he gives no details. Fire crack formation was minor in mills where high operating speeds permitted small reduction at the beginning of the rolling process.

Moses[3] states that the elimination of fire cracking on primary mill rolls would be a mixed blessing. The problem is to control it, both by mill practice and by roll composition and heat treatments, and have it serve a useful purpose. It must not become so coarse or deep as to damage the surfaces of the rolled product. In his opinion radial penetration should not be more than $\frac{3}{16}$ to $\frac{1}{4}$ in. for economical roll life and that actually, it must not penetrate so deeply as to cause breakage of the roll.

A method mentioned (2, 3, 6, 7, 9, 11) for controlling fire cracking is knurling, which has been used in different designs on steel blooming and slabbing mill rolls. Perhaps the most important thing claimed for knurling is that it minimizes deep-seated fire cracking and consequently decreases roll breakage. It changes the fire crack patterns and decreases the amount of dressing necessary to completely remove fire cracks. Knurling is believed effective because it does not allow concentration of heat or steam and because the compressive stresses[8] introduced in the surface layer during knurling must be overcome before fire cracking can occur. The notches knurling provides presumably modify the direction of principal stresses and interfere with extension of cracks.

Knurling[4] is satisfactory for rolling sheet and tin plate or for secondary mills which roll low-carbon steel but not for rolling flat forged product because it leaves roll-scale marks. In one mill[10] where it was tried it was not satisfactory because of large roll spalls. Knurling gives some control of fire cracking, but knurling itself is not enough to completely control fire cracking as shown in Figure 7.

Water cooling is also effective as a method of control.

Fire cracking in blooming and slabbing mill rolls has been most readily minimized[6] by control of heat—usually carefully arranged water cooling. This was also found true in forged steel rolls in hot strip mills wherein a decrease in roll life from a high rolling rate can be counteracted[12] by increasing the amount of cooling.

Regarding the second category, structural-mill rolls, there was only one paper which discussed fire cracking in these rolls.

Goebel[13] discusses nodular-iron rolls that developed fire cracks parallel to the axis in the passes used for rolling angle bars. These were 24¼ x 39-in. finishing-planishing rolls (55 Shore) used for rolling bars up to 800 ft long. He believes that exceptionally strong water cooling is necessary in such applications.

He also mentions that in mills for rolling rails, I-

Figure 7 — The area containing this 10-in. circumferential crack has had its knurling machined-off. The roll appears to have been subjected to a sticker sometime during its service life.

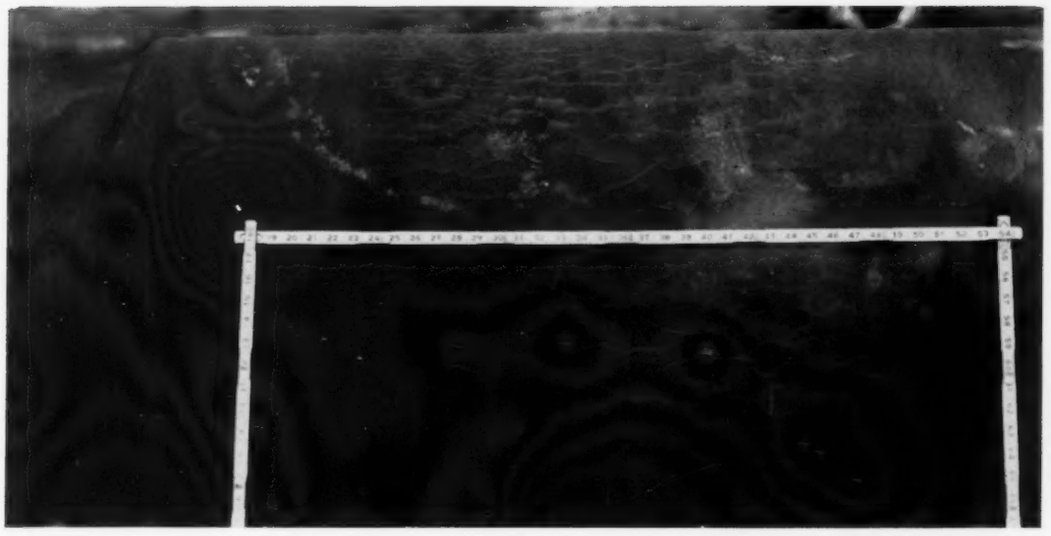


Figure 8 — A fire-cracked pattern on a 26 ¼ x 54-in. iron hot strip mill roll has most of its cracks oriented in a longitudinal direction. This illustration is reduced by a factor of 9.6.

beams and channels, an important "sliding" friction occurs, which increases the danger of fire cracks.

Regarding the third category; fire cracking in hot strip mill work rolls was discussed in several papers.

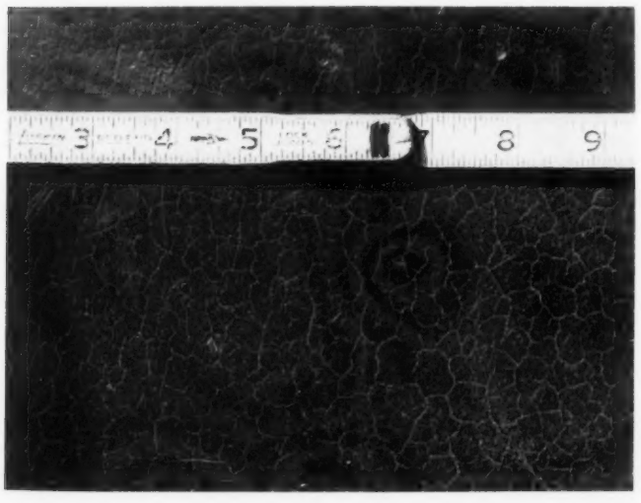
Buhler[12] in his discussion of forged steel rolls supports Keller's theory about the origin of cracks. He adds that with a regular rolling rate more cycles can be expected before the first fire cracks appear than when rolling with longer idling periods. The idling periods increase the temperature difference between the roll surface being water-cooled, and the hot steel being rolled; thus increasing the danger of fire cracking.

Hesse,[14] in his discussion of Buhler's paper, says that tensile stresses which can occur in the surface layer of the roll during idling are the cause of fine fire cracks forming. He also says[2] that in uncooled (dry rolling) steel hot mill rolls, a thin surface layer is plastically deformed after the first passes because of the high residual compressive stresses. Then, fire cracks can probably occur because of the rapid heat transfer toward the cool core.

As to the fire crack patterns in hot strip mill work rolls, Hesse[2] states that high-thermal gradients produce mainly tangential tensile stresses. For example, in a 4-high strip mill roughing stand which he observed, longitudinal cracks are more prevalent than circumferential cracks. This indicates the effect of thermal stresses, with very little bending stresses present because of the support given by the backup rolls. Fire cracks that are predominant in the longitudinal direction are shown in Figure 8.

In the general statement not specifying iron or steel rolls, Hesse[2] recommends increasing the number of passes by decreasing the amount of reduction during the first passes. He says such practice in 4-high hot strip mill roughing stand almost eliminated fire cracks on work rolls. By lowering the pressure and decreasing the area of contact between roll and slab, the amount of heat transferred was decreased. Intensive surface cooling to eliminate cracks was not successful, which Hesse says confirms his opinion that plastic deformation of the roll surface occurs at the beginning of the rolling process if the amount of reduction per pass is not decreased.

Figure 9 — Reduced by a factor of 2.28, this honeycomb fire crack pattern is on an iron roll used in a 44-in., 2-high reversing rougher in a hot strip mill. The size of the pattern is 3/16 to 3/8 in. diameter.



Hesse[2] states that in a grain-type cast iron roll from a Steckel mill, magnification was needed to see the fire cracks. A microscopic examination showed that all the cracks occurred between the ends of the graphite particles which apparently acted as notches. An example of a pattern on an iron roll appears in Figure 9.

Allison and Peterson[6] say that the small particles of graphite in a grain-type roll which are about 0.001 to 0.005 in. in diameter seem to improve strength and resistance to fire cracking and wear. Chill-type rolls contain none of this free graphite in the surface layers.

Goebel[13] supports these authors when he says that grain-type and nodular-iron rolls are superior to chill-type rolls concerning resistance to fire cracking. However, he tells of a trial in a 3-high finishing stand where medium-hard grain-type iron rolls (34 x 90 in.) alloyed with chromium, nickel and molybdenum developed severe fire cracks which required considerable dressing after each roll change. His opinion was that insufficient cooling might be the cause of this fire cracking.

Regarding the fourth and last category, nonferrous mill work rolls, Thomas Firth and John Brown, Ltd.[15], state that the mosaic-type fire cracks in forged steel rolls used for rolling aluminum slabs are only a few thousandths of an inch deep, and that they are evidently due to stresses in the surface layer. For rolls 35 x 90 in., the roll surface temperature is calculated as fluctuating between 750 and 175 F with a water-oil-emulsion cool-

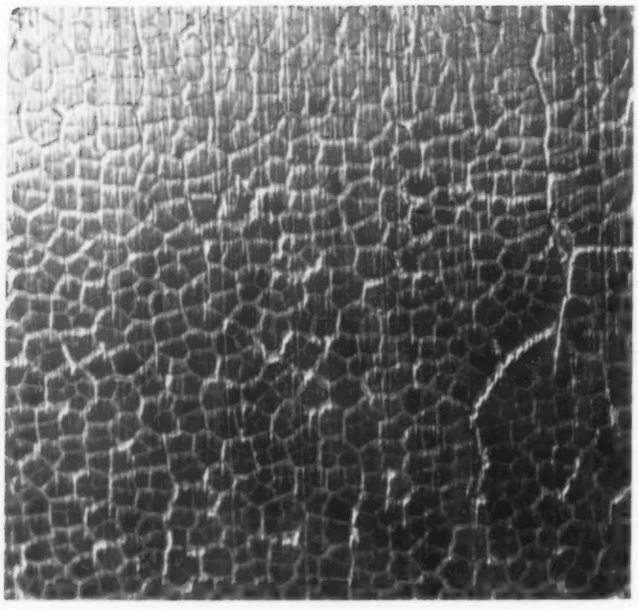


Figure 10 — This mosaic fire crack pattern, shown full size, is on a steel roll for breaking down copper. The size of the pattern areas is $\frac{3}{32}$ to $\frac{1}{8}$ in. diameter.

ant. A very steep thermal gradient exists, with a calculated temperature (Schmidt layout method) of 390 F at a depth of 0.012 in. below the surface when the surface is at 750 F. (Writer's comments: The aluminum temperature is only 900 to 950 F, therefore the roll surface temperature is probably less than 750 F.)

According to Adams[16] the grinding of a steel roll in the mill with an abrasive on a wooden stick may cause fire cracking because of the rapid generation of heat. This polishing procedure has been used in nonferrous practice to clean the rolls.

He also mentions that fire cracking on hardened steel rolls occurs in nonferrous rolling because of large differences in velocity between the surface of the roll and the metal being rolled when heavy reductions are taken on thick metal. An example of a fire crack pattern on a steel roll used for rolling copper is shown in Figure 10.

Hesse[2] states that honeycomb-shaped cracked areas on steel rolls for a 3-high brass roughing stand have often been blamed on tearing of primary grain boundaries. But he disagrees because only longitudinal cracks occur outside the strip width, and because photomicrographs showed that the cracks were trans-granular. In chilled cast-iron rolls the cracks are through the ledeburite phase. He also says that the honeycomb-shaped pattern is obviously caused by excessive longitudinal and tangential tension stresses which are greatest at the surface during water cooling because the heat flow toward the core is small. He gives examples of this with an alloy cast steel roll (65 Shore), a forged steel roll and a chilled cast iron roll.

Waine[17] mentions that during hot rolling of soft metals such as brass and aluminum the metal intrudes or forces its way into the cracks and tends to force them open.

Adams[16] says that to overcome fire cracking in hardened steel rolls, which occurs when heavy reductions are taken on thick nonferrous metal, a special analysis and method of manufacture were developed. However, he gives no details. Many of these rolls were shipped to the mills with a sand-blasted or grit-blasted surface, since fire cracking caused by sliding friction was largely retarded by such surfaces.

Waine[17] in discussing fire cracking in rolls used for breaking-down aluminum alloy and copper-base alloy ingots says forged steel rolls are more resistant to fire cracking than chilled iron. The hardness of the steel rolls is very important: If it is too low, fire cracking develops rapidly, if it is too high spalling occurs. He says a hardness of 50 to 55 Shore has proved satisfactory for many different steel roll compositions.

During an informal meeting of the nonferrous metals industry, British rollmakers[18] contended that when chilled iron or steel rolls fire cracked, the remedy lay with the roll users. They should either modify their rolling technique, or remove the cracking in its early stages by redressing.

SUMMARY

According to the present survey, fire cracking occurs on rolls for blooming and slabbing mills, structural mills and hot strip mills. This phenomena also occurs on rolls in mills for hot rolling copper, brass and aluminum. Mild fire cracking is sometimes considered beneficial in promoting "bite" in roughing mills. However, in most applications fire cracking is considered undesirable and definite efforts are made to control it.

Fire cracking is believed to be caused primarily by stresses due to thermal cycles in the surface layers of a roll having a relatively cool core. The thermal stresses are related to the intensity of the heat source and the rate of heat removal from the surface. Bending stresses, contact stresses and residual stresses (if present) combine with these thermal stresses. When the combined tension stresses reach a sufficiently high level in the roll surface-layer and cannot be relieved by further plastic flow, the initial crack formation occurs.

Fire cracks occur in the surface layer, perpendicular to the major stress or stresses and may extend either through grains or along the grain boundaries of the metal. The resultant cell shape of the fire crack pattern depends upon the direction of major stresses.

Rolling at abnormally heavy draft, and rolling accidents such as "stickers," promote the starting of fire cracking. Tool marks or saw-toothed stress raisers produced in normal machining may promote crack formation in areas stressed in tension on the surface. Continued thermal cyclic stressing deepens and widens the fire cracks already formed, and these act as notches in promoting growth. Other factors that promote crack growth include oxidation, super-heated steam or gas pressure and mechanical stresses such as those produced by bending.

Procedures that have helped to control fire cracking are: eliminating stress raisers formed during machining, preheating the rolls, using light drafts during the warm-up period of a roll to minimize contact area and bending stresses, avoiding ingots or slabs "sticking" part way through the roll gap, using a regular rolling rate and using adequate cooling water. Roll makers can help to a moderate extent in controlling fire cracking by providing the most suitable roll composition and heat treatment for each installation.

It has sometimes been useful to introduce surface compressive stresses to counteract the tension stresses that cause fire cracking. This may be done by cold work-

ing the surface by peening, knurling and shot blasting. Frequent roll dressing has been used to remove a thin surface layer containing micro cracks caused by fatigue.

Fire cracking is the result of reaching the fatigue endurance limit—expansion-contraction repeating until the material fails.

Fire cracking can probably be decreased in two ways: by improving the thermal fatigue resistance of the roll material, and research is regularly being conducted along these lines, and by decreasing the thermal forces which are imposed upon the roll by the thermal gradients.

There is a limit to the fatigue resistance that can be imparted—the big thing would be to reduce thermal gradients, and this can be done by proper control of heat input and heat removal.

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16. "Forged Steel Rolls," by J. Adams, *AISE Proceedings*, 1938, p. 48.
17. "Forged Steel Rolls: A Review of Their Applications and Manufacture," by A. H. Waine, *Journal Iron & Steel Inst.*, 1950, Vol. 165, p. 279.
18. "Rolls and Their Maintenance in the Non-Ferrous Metals Industry," *Bulletin Institute of Metals*, 1953, Vol. 1, p. 199. (An informal discussion.)

Discussion

PRESENTED BY

A. A. BRADD, Co-ordinator of Rolls, Midvale-Heppenstall Co., Nicetown, Philadelphia, Pa.

N. R. ARANT, Technical Director, Roll Manufacturers Institute, Pittsburgh, Pa.

V. GARG, Trainee, Homestead Works, United States Steel Corp., Munhall, Pa.

A. A. Bradd: One of the possible sources of residual stress in a roll is the tempering effect on the rolling surface when the temperature produced by the material being rolled exceeds the draw temperature used to produce the hardness in the roll. Steel expands when it is hardened; it contracts when it is tempered. If the surface is tempered by the rolling action, it will produce a residual tensile stress in the surface. This is on forged steel rolls.

We have had some sad experiences with fire cracking of rolls used for hot rolling aluminum that were ordered to too high a hardness range. We found that the temperatures produced by rolling reduced the surface hardness and they fire cracked after very short service. The rolls were retempered at a higher temperature to reduce their hardness so that no further reduction in surface hardness occurred in service. After this was done, they worked successfully, with no fire cracking.

N. R. Arant: There are several references in the literature, other than those referring to rolls, mentioning that some cases of fire cracking are probably caused by phase changes in a thin, surface layer.

Other than knurling, I found no mention of surface rolling of rolls to introduce residual compressive stresses. However, one thing may be related which does not even pertain to metals. For example, in chinaware the makers intentionally formulate the thin layer of ceramic glaze so that it is put into compression when the piece is cooled to room temperature and by so doing avoid crazing, which is similar to fire cracking in appearance. On the other hand, if a crazing pattern is specifically desired on a ceramic art piece, the glaze formula is selected so that when it cools it goes into tension and immediately cracks in all directions producing a typical crazing pattern.

V. Garg: In the 54-in. blooming mill at Homestead the rolls used to have 59-in. nominal diameter, and it was believed that more tonnage of steel could be rolled because of a larger number of possible dressings on this big roll. However, it has been observed that rolls crack much earlier and that they reach the scrap size and the extra cost involved is not justified for making so large rolls. The plans are to shift to 57-in. nominal diameter.

N. R. Arant: I believe the question refers to ordering rolls larger in diameter than normal to allow for machining off a thin layer as fire cracking occurs. I believe it is generally agreed that regularly removing a layer containing small cracks is beneficial. In fact, in the literature—this again is not referring to rolls—it is reported that by removing thin layers containing micro cracks in a steel fatigue specimen nine times during the life of the specimen, the life was increased 6½ times. This beneficial effect, which was accomplished by repeatedly removing thin layers when cracks started forming, would probably hold true for roll surfaces too.

In concluding these comments, we want to emphasize that much work has been done and published on fire cracking and craze cracking in other materials than rolls; particularly in die-casting dies, brake drums, gun tubes, railway-car wheels and iron glass-molds. Since the cracks in all of these cases tend to form surface patterns similar to those on rolls, the mechanisms probably are related, and some of the principles relating to metals, ceramics and plastics may be applicable to rolls. This work, although outside the exact field of rolls, should be utilized in future studies of roll fire cracking. ▲

CURRENT AISE DISTRICT SECTION MEETING NOTICES

BIRMINGHAM SECTION

Friday, December 11, 1959
Christmas Dinner and Dance
Social Hour 6:30 P.M.
Dinner 7:30 P.M.
Dancing 9:00 P.M. to 12 M.
Thomas Jefferson Hotel, Birmingham, Ala.

BUFFALO SECTION

Saturday, December 12, 1959
Christmas Dinner and Dance
Social Hour 7:30 P.M.
Dinner 8:00 P.M.
Dancing 9:00 P.M. to 1:00 A.M.
Golden Ballroom, Hotel Statler Hilton, Buffalo, N. Y.

CANTON SECTION

Saturday, December 19, 1959
Christmas Dinner and Dance
Social Hour 6:30 P.M.
Dinner 7:00 P.M.
Dancing 9:30 P.M. to 1:00 A.M.
Mergus Restaurant, Canton, Ohio

CHICAGO SECTION

Saturday, December 5, 1959
Christmas Dinner and Dance
Dinner 7:00 P.M.
South Shore Country Club, Chicago, Ill.

CLEVELAND SECTION AND YOUNGSTOWN SECTION

Saturday, December 5, 1959
Christmas Dinner and Dance
Social Hour 7:00 P.M.
Dinner 7:30 P.M.
Cleveland Engineering & Scientific Center,
3100 Chester Avenue, Cleveland, Ohio

COLORADO SECTION

Thursday, December 10, 1959
Christmas Party, 7:00 P.M.
Silver Moon Restaurant and Lounge,
2001 Santa Fe Drive, Pueblo, Colo.

DETROIT SECTION

Saturday, December 5, 1959
Christmas Dinner and Dance
Social Hour 6:30 P.M.
Dinner 7:30 P.M.
Dancing 9:00 P.M. till ?
Detroit Yacht Club, Belle Isle, Detroit, Mich.

LOS ANGELES SECTION

Saturday, December 5, 1959
Christmas Dinner and Dance
Dinner 7:00 P.M.
Statler Hotel, Los Angeles, Calif.

PHILADELPHIA SECTION

Saturday, December 5, 1959—Dinner 6:00 P.M.,
Meeting 7:00 P.M.

"New 140-In. Roughing and Slabbing Mill"—Lukens Steel Company, Coatesville, Pa.

"**Building Layout and Facilities,**" by Leo R. Daiuta, Construction Engineer, Engineering and Construction Div., Lukens Steel Co., Coatesville, Pa.

"**Water Systems,**" by V. R. McGibbon, Design Engineer, Engineering and Construction Div., Lukens Steel Co., Coatesville, Pa.

"**Roll Grooving,**" by E. A. Berry, Superintendent Machine and Forge Dept., Maintenance Div., Lukens Steel Co., Coatesville, Pa.

Engineers' Club, 1317 Spruce Street, Philadelphia, Pa.

PITTSBURGH SECTION

Saturday, December 12, 1959
Christmas Dinner and Dance
Dinner 8:00 P.M.
Dance 9:00 P.M.
Penn-Sheraton Hotel, Pittsburgh, Pa.

ST. LOUIS SECTION

Saturday, December 5, 1959
Christmas Dinner and Dance
Dinner 7:00 P.M.
Dancing 9:00 P.M. to 1:00 A.M.
Elks Club, Granite City, Ill.

SAN FRANCISCO SECTION

Saturday, December 5, 1959
Christmas Party
Social Hour 7:00 P.M.
Dinner 8:00 P.M.
Dancing 9:00 P.M.
Mt. Diablo Country Club, Danville, Calif.

UTAH SECTION

Friday, December 4, 1959
Christmas Party 6:30 P.M.
Salt Lake City Country Club, Salt Lake City, Utah

Some of the advantages of this process are the ease with which carbon is controlled and its ability to process ores contaminated with titanium, manganese and chromium . . . . the floating charge operation of the electric smelting furnace permits carbon monoxide to be used as a heat source for the pre-reduction rotary kiln, thus making the process more efficient thermally.

The Strategic-Udy Direct Iron Reduction Process

by Dr. Marvin J. Udy,* Vice President, Strategic-Udy Processes, Inc., Niagara Falls, N. Y.
and Robert A. Blackburn, Sales Engineer, Koppers Co. Inc., Pittsburgh, Pa.

ELECTRIC furnace smelting is a relatively old art and many products such as carbides, phosphorus ferroalloys have been produced through this medium. In the past, particularly on this continent, such smelting has been mainly concerned with the preparation of materials in the higher value brackets. However, in other parts of the world electric furnace smelting has been used successfully to reduce iron ore and to serve as the raw material process base for a steel industry. Heretofore in order to produce iron economically by this type of smelting, certain economic yardsticks had to be applied to measure the practicality of the process. These salient economic factors were:

1. Low cost electrical power.
2. Nonavailability or high price of good coking coals.
3. Minimum economic capacity limitations of blast furnace—coke oven method.
4. Necessity for iron production due to high price or unavailability of scrap.
5. Necessity for low capital cost.

While it is impossible to generalize, over this broad range, it might be stated with suitable qualifications that electric furnace smelting in the past was attractive under one or more of the following conditions:

1. Power cost below 6 mils per kwhr.
2. Coking coal costs above $15.00 per ton.
3. Plant capacity under 1000 tons iron per day.
4. Scrap cost above $50.00 per ton.
5. Necessity of minimum capital cost.
6. High quality iron ore.

With the use of new techniques now developed in the electric furnace smelting field, many of the past economic factors have been considerably altered. For example, power requirements may be cut in half, thus doubling furnace capacity and thereby reducing capital expenditures and operating costs per unit of capacity. Control of material quality has been improved thus reducing subsequent costs in the refining to steel of the iron produced in the smelting furnace. Another factor is the ability to use in whole or in part iron ores that are not desirable feeds for blast furnaces. Such ores may have an appreciable price advantage over conventional shipping-grade iron ores.

The advance in techniques is mainly concerned with a reduction of the power required for smelting and with the use of a variety of carbonaceous materials as suitable reductants. The saving in electric power is largely achieved by preheat and prereduction of the charge to the furnace whereas the use of relatively inexpensive reductants tends to make the process more widely applicable.

In view of the improvements to electric furnace smelting practice it is quite likely that the North American continent will install several iron smelting electric furnaces within the next few years.

STRATEGIC-UDY DIRECT IRON REDUCTION PROCESS

The Strategic-Udy direct iron reduction process is a smelting technique utilizing a direct-fired rotary kiln

* Deceased.

for partial prereduction of iron ore before charging to an electric arc smelting furnace. A substantial portion of the heat required for the prereducing and preheating of the iron ore in the kiln is supplied by burning the carbon monoxide gas produced from the reduction reactions of the electric arc smelting furnace. The essential equipment for the process is shown in Figure 1.

A mixture of iron ore, flux and carbonaceous reductant is continuously fed to the rotary kiln. During the operation, the iron ore is heated, calcined and prereduced; and the flux (limestone or dolomite) is calcined and combined chemically with the ore. The maximum temperature of the free-flowing discharge from the kiln is controlled at some temperature between 1800 and 2300 F, varying for different ores. Beyond this temperature, the hot charge material starts to cake and adhere to the walls of the kiln forming a ring. Sufficient coal is added to the kiln to accomplish the 2-step reduction that is required. The coal which is not utilized in the prereduction or burnt in the kiln is "coked" in the kiln and passes out with the prereduced material for use as a preheated reductant in the electric smelting step.

To save thermal and electrical energy, the hot prereduced ore from the kiln is charged directly to the smelting zone of the electric smelting furnace through insulated feed control bins and controlled feeders. The direct iron process employs an open bath technique with the electrodes from ½ in. above the molten slag to 3 in. submerged in the slag, depending upon the needs of the particular operation. The charge material enters the periphery of the furnace and forms its own angle of repose. Thus the space above the electrodes is open and offers no restriction to the flow of carbon monoxide gas produced during the reduction reaction, and the molten bath in the furnace furnishes a constant electrical resistance thus permitting high and uniform power inputs. The use of such a charging technique permits the charging of fines without interference with the operation. The reaction between the coal and the iron oxides in the molten bath is extremely rapid, resulting in the fast liberation of carbon monoxide gas. This gas is collected and burnt in the kiln to supply a major portion of the heat of the kiln.

With the Strategic-Udy electric furnace technique it is possible to vary the carbon content from pig iron at 3.5 per cent carbon to semi-steel at 0.2 per cent carbon with comparative ease. Accurate control of the slag composition permits selective smelting to remove contaminating elements such as titanium, manganese, phosphorus, chromium and nickel and also permits high recovery of iron. These contaminating elements can be recovered for credit if present in sufficient concentration. Where exact carbon control of the iron is required, finishing additions of reductant can be introduced in the smelting furnace or carbon adjustments made by the addition of iron ore.

The balance of the operation is similar to conventional smelting techniques. The iron and slag are tapped intermittently and handled in the conventional manner.

The reduction process is capable of accurate control, and unwanted materials can readily be separated from the iron. A study of the free energies and equilibria of the various reduction reactions will establish the oxides that can be expected to stay in the slag. Oxides of chromium, manganese and titanium are examples of materials that can be left in the slag. In the case of oxides of copper, cobalt and nickel, it will be noted that they are more readily reduced than iron, and thus a selective reduction step would be required if iron ores contain these materials. Figure 2 indicates the free energy-temperature relationships for the principal reduction reactions. Those reactions which have the higher negative values are more likely to proceed to completion than those which have lower negative, or positive free energies of formation. Therefore, by control of the degree of reduction through controlled use of carbon, it is possible to practice selective reduction with an ore. In the case of a blast furnace it is necessary to add an excess of reductant

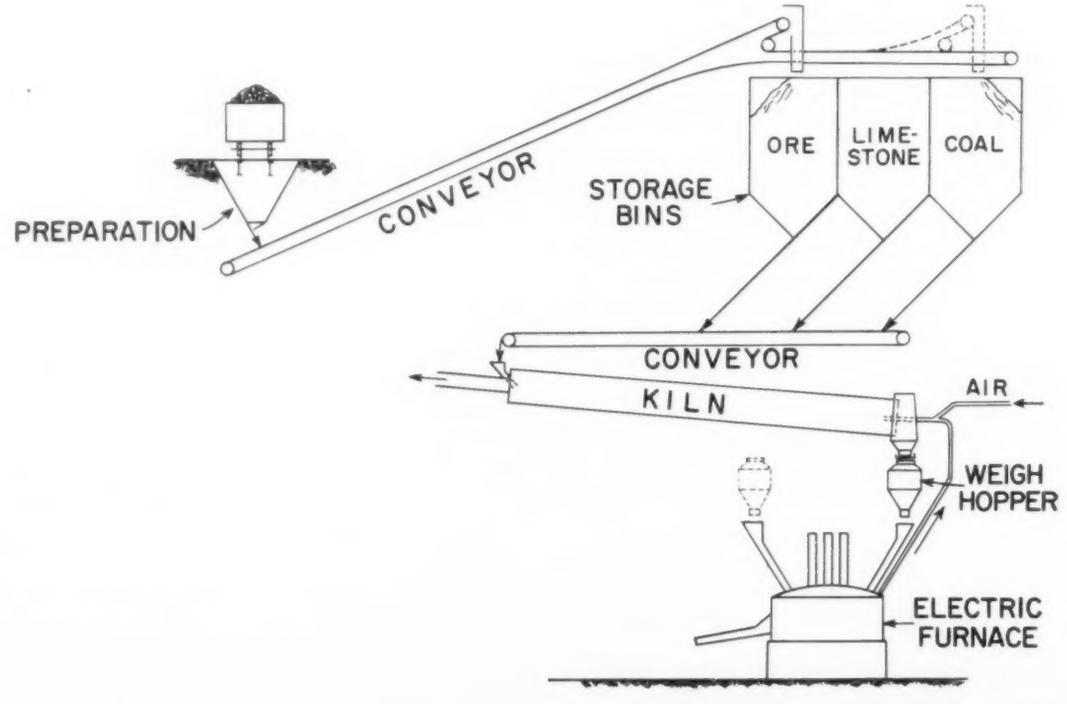


Figure 1 — Schematic shows Strategic-Udy process.

and by its combustion make sufficient heat available for bringing the charge to temperature. Such an excess of carbon makes the selective reduction process impractical in a blast furnace.

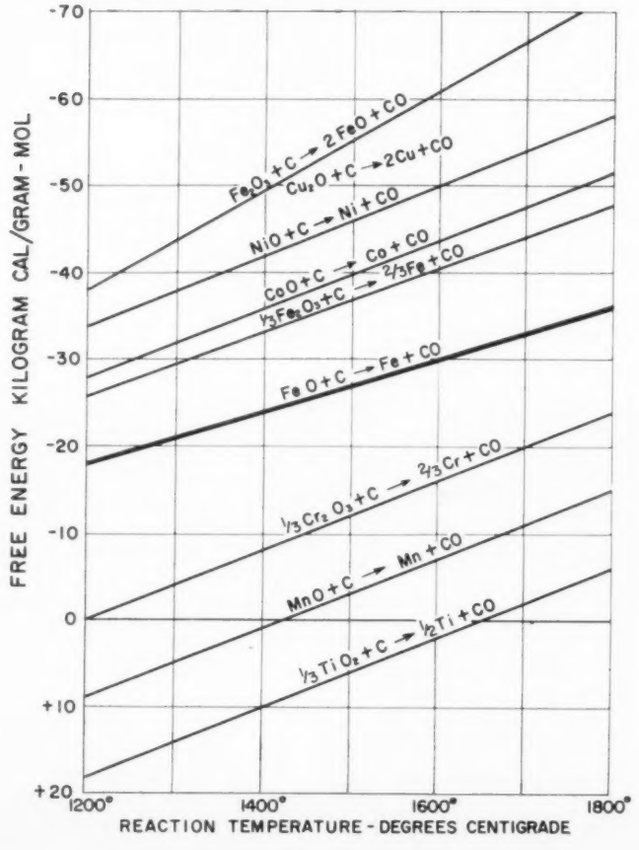
At Niagara Falls, Ontario, a prototype plant has been used to demonstrate the Strategic-Udy iron reduction processes. The facilities available at the plant are as follows:

1. Three 1000-kva (modified in design) 3-phase electric smelting furnaces.
2. One 6-ft diam x 80-ft long rotary kiln. The kiln is gas or oil-fired and with a dust collector and fan. The kiln has weighing equipment for measuring kiln feed.
3. Crushing, drying, conveying and storage bin equipment.
4. Two bridge cranes, each having a capacity of 15 tons on the main hook, with an auxiliary hoist of 5-ton capacity.
5. Complete ladle, molds, chills and sundry equipment.
6. Complete laboratory equipment for quality control and for making chemical analyses.

MATERIAL AND ENERGY REQUIREMENTS

The following calculations are made in order to establish the amount of material and energy required to produce iron by the Strategic-Udy process. These calculations are of a rough nature and do not have some of the refinements that would properly satisfy perfec-

Figure 2 — These curves of free energy vs temperature for the principal reduction reactions show how, by control of the degree of reduction through controlled use of carbon, it is possible to selectively reduce ore.



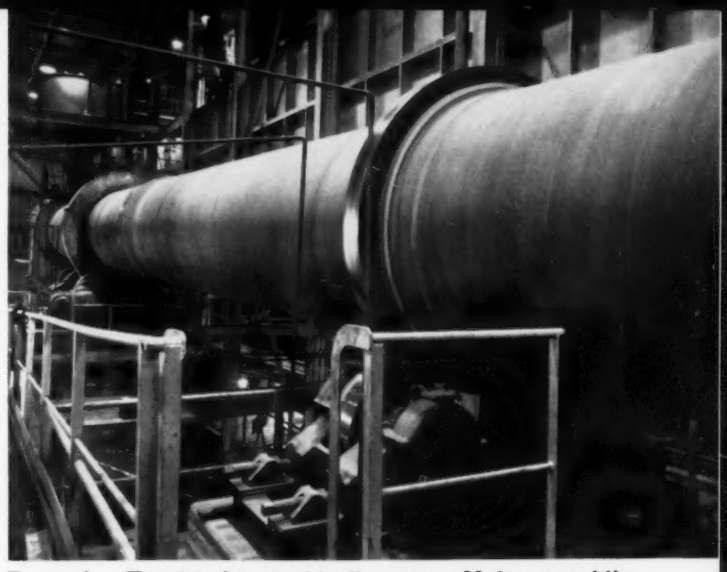


Figure 3 — The 4 ft-6 in. inside diameter x 80-ft rotary kiln receives the charge of ore, flux and fuel.

tionists. However, the results are in the proper order of magnitude. It is possible to use the following form to calculate the possibilities of the process with various ore analyses and with various costs of materials. In the following example a typical shipping iron ore has been used.

Data

1. Input based on 300 tons per day of pig iron or 105,000 tons per year.
2. Typical ore analysis (dry):

Fe	58.66	CaO	0.22
P	0.084	MgO	0.04
SiO_2	7.54	S	0.006
Mn	1.12	Loss on ignition	5.92
Al_2O_3	1.34	Assumed combined O_2	25.07

3. Calculated ore analysis (dry):

Fe_2O_3	83.90	CaO	0.22
P_2O_5	0.192	MgO	0.04
SiO_2	7.54	S	0.006
MnO	1.45	Loss on ignition	5.92
Al_2O_3	1.34		

4. Recovery of iron taken as 95 per cent.
5. Prereduction in kiln taken as 37 per cent of Fe requirements reduced to metal, rest to FeO. This amount of prereduction has been exceeded in a recent run in the prototype plant at Niagara Falls, Ontario.
6. Sufficient coal is added in the kiln to reduce all the iron oxide. The coal not used in kiln prereduction will be coked and serve as a preheated reductant in the electric furnaces.
7. Pig iron is considered to have the following percentage analysis:

Fe	98.5
Si	0.2
C	0.8
Other elements	0.5
	100.0

8. Cost of materials and power:
   a. Ore cost, $11.75 per ton
   b. Limestone, $2.00 per ton
   c. Coal, $9.00 per ton
   d. Oil, $0.10 per gal
   e. Power, $0.006 per kwhr.

Calculations on rotary kiln

a. Ore requirements

$$\frac{0.985 \times 300}{0.95 \times 0.5866} = 530 \text{ tons ore per day}$$

$$= \frac{530}{300} = 1.77 \text{ tons ore per ton pig iron}$$

b. Limestone charged to kiln

1. Tons per day $P_2O_5 = 530 \times 0.00192 = 1.02$ tons per day

Lime required to form $4CaO\ P_2O_5 = 1.02 \times \frac{4 \times 56}{142} =$

Figure 4 — The kiln product, a free-flowing sinter, is discharged into insulated hoppers at high temperature.

1.6 tons per day

2. Tons per day $SiO_2 = 530 \times 0.0754 = 39.9$ tons per day
   Equivalent lime required to form $2CaO \cdot SiO_2 = 39.9 \times \frac{2 \times 56}{60} = 74.7$ tons per day
3. Total equivalent lime available $= 0.0022 + 1.4\,(0.0004)$ $= 0.276$ per cent, $0.00276 \times 530 = 1.46$ tons per day
4. Total lime required: $(1.6 + 74.7) - 1.46 = 74.84$ tons per day lime or 150 tons per day limestone $= 150/300 =$ 0.50 ton limestone per ton pig iron

e. *Coal requirements*—Sufficient coal for all reduction is added to the kiln feed plus 10 per cent excess carbon.

Reactions:

1. $Fe_2O_3 + 3C = 2Fe + 3CO$
2. $SiO_2 + 2C = Si + 2CO$
3. $P_2O_5 + 5C = 2P + 5CO$

1. Iron from Fe_2O_3:
   $0.5866 \times 530 = 311$ tons Fe in Fe_2O_3
   $C = 311 \times \frac{36}{111.7} =$ 100.0
2. Si in iron:
   $0.002 \times 300 = 0.60$ ton Si
   $C = 0.60 \times \frac{24}{28.09} =$ 0.52
3. Phosphorus:
   $0.00084 \times 530 = 0.445$ ton P
   $C = 0.445 \times \frac{60}{2 \times 30.975} =$ 0.43
4. Carbon in pig iron
   $C = 0.008 \times 300 =$ 2.4

Total carbon (tons per day) 103.35

Amount of carbon required $= 1.10 \times 103.35 = 113.7$ tons per day

Assume 80 per cent fixed carbon

$$\text{Coal to kiln} = \frac{113.7}{0.80} = 142 \text{ tons per day}$$

$$= \frac{142}{300} = 0.473 \text{ ton coal per ton pig iron}$$

d. Heat duty of kiln

1. Heat to raise temperature 1800 F:

Coal	142 tons
Limestone	150 tons
Ore	530 tons
	822 tons

   $822 \times 2000 \times 1800 \times 0.225 =$ 665,820,000
2. Heat for volatiles (loss on ignition)
   $530 \times 2000 \times 1350 \times 0.0592 =$ 84,600,000
3. Heat for prereduction
   a. $Fe_2O_3 + C = 2\,FeO + CO$ $- 76{,}824$ Btu per lb mol
      $311 \times 2000 \times \frac{76{,}824}{111.7} =$ 427,000,000
   b. $FeO + C = Fe + CO$ $- 67{,}151$ Btu per lb mol
      $0.37 \times 0.985 \times 300 \times 2000 \times \frac{67{,}151}{55.85} =$ 263,000,000
4. Heat for calcining limestone
   $150 \times 2000 \times 764 =$ 229,200,000

Net heat requirements (Btu per day) 1,669,620,000

a. 70 per cent thermal efficiency:
   $\frac{1{,}669{,}620{,}000}{0.70} = 2{,}385{,}171{,}000$ Btu per day

e. Calculation of heat input to kiln

1. Heat from CO produced by prereduction:
   a. $CO + \frac{1}{2}\,O_2 = CO_2 + 121{,}745$ Btu per lb mol
   b. CO produced in kiln:
      From FeO formation—
      $311 \times 2000 \times \frac{28}{111.7} = 155{,}900$
      From Fe formation—
      $0.37 \times 985 \times 300 \times 2000 \times \frac{28}{55.85} = 109{,}600$
      Lb of CO formed $= 265{,}500$
   c. Heat from combustion
      Lb mol CO $= \frac{265{,}500}{28} = 9480$
      $9480 \times 121{,}745 = 1{,}154{,}000{,}000$ Btu per day

Figure 5 — The hot sinter from the kiln is then charged into the reaction zone of the electric smelting furnace.

Figure 6 — Closeup of hoppers for feeding charge into electric furnace.

2. Heat from combustion of excess carbon (Assume 20 per cent of excess carbon is lost in waste gas):
   a. Excess carbon = $10.35 \times (1 - 0.20) = 8.28$ tons per day
   b. Heat of combustion = 169,294 Btu per lb mol
   c. Mols of carbon burnt = $8.28 \times \frac{2000}{12} = 1380$ lb mols per day
   d. Heat supplied = $1380 \times 169{,}294 = 233{,}625{,}720$ Btu per day
3. Heat internally supplied in kiln

a. From prereduction gas	1,154,000,000
b. From combustion of excess carbon	233,625,720
c. Heat from volatile matter of coal if ½ of volatile matter heat utilized $142 \times 0.10 \times 2000 \times 14{,}500 \times 0.5 =$	205,900,000
Total heat internally supplied (Btu per day)	1,593,525,720

f. Calculation of external heat required in kiln

Heat duty of kiln	2,385,171,000
Heat input to kiln (internal)	1,593,525,720
Net external heat required (Btu per day)	791,645,280

There is an excess of furnace gas over that required by the kiln, and no auxiliary heat is needed.

Calculation of electric furnace

a. Furnace Burden

1. From ore

	Tons per day
$Fe = 0.37 \times 0.985 \times 300$	= 109.3
$FeO = (310.9 - 109.3)\frac{71.85}{55.85}$	= 259.4
$SiO_2 = 0.0754 \times 530$	= 39.9
$Al_2O_3 = 0.0134 \times 530$	= 7.1
$CaO = 0.0022 \times 530$	= 1.17
$MgO = 0.0004 \times 530$	= 0.21
$P_2O_5 = 0.00192 \times 530$	= 1.02
$MnO = 0.0145 \times 530$	= 7.67

2. From limestone (Neglect gangue)

CaO	= 74.84

3. From coal

Assume 10 per cent ash = $0.10 \times 142 = 14.2$ tons per day	
Assume ash analysis:	
$SiO_2 = 0.50 \times 14.2$	= 7.1
$Al_2O_3 = 0.43 \times 14.2$	= 6.1
$FeO = 0.05 \times 14.2$	= 0.7
$CaO = 0.02 \times 14.2$	= 0.28
$C = \frac{12}{28} \times 101 + 300 \times 0.008$	= 45.7
	560.49

Furnace Burden	Tons per day	Per cent
Fe	109.3	19.5
FeO 259.4 + 0.7	260.1	46.4
SiO_2 39.9 + 7.1	47.0	8.39
Al_2O_3 7.1 + 6.1	13.2	2.36
CaO 1.17 + 0.28 + 74.84	76.29	13.61
MgO	0.21	0.04
P_2O_5	1.02	0.18
MnO	7.67	1.37
C	45.7	8.15
	560.49	100.00

b. CO produced

1. $FeO + C = Fe + CO$

Other reactions producing CO neglected, CO from FeO

$260.1 \times \frac{28}{71.85} = 101$ tons per day

Cu ft of CO produced = $101 \times 2000 \times \frac{378}{28} = 2{,}730{,}000$ cu ft per day

Gas per ton pig iron = $\frac{2{,}730{,}000}{300} = 9100$ cu ft gas per ton pig iron

Btu heating value = $2{,}730{,}000 \times 321.7 = 877{,}000{,}000$ Btu per day

c. Thermal requirements for electric furnaces

1. Reactions involved:
   a. $FeO + C = Fe + CO$ $-67{,}151$ Btu per lb mol
   b. $SiO_2 + 2C = Si + 2CO$ $-274{,}103$ Btu per lb mol
   c. $P_2O_5 + 5C = 2P + 5CO$ $-410{,}255$ Btu per lb mol
2. Heat required for reactions
   a. For reduction of FeO
      $260.1 \times 2000 \times \frac{67{,}151}{71.85} = 486{,}178{,}800$
   b. For Si in metal
      $300 \times 0.002 \times 2000 \times \frac{274{,}105}{28.09} = 11{,}700{,}000$
   c. For P in metal
      $1.02 \times 2000 \times \frac{410{,}255}{141.95} = 5{,}920{,}000$

   Total heat for reaction (Btu per day) 503,798,800
3. Heat required to raise hot charge 1000 F:
   Sensible heat—
   $560.49 \times 2000 \times 1000 \times 0.225 = 252{,}220{,}500$
   Heat of fusion—
   $(560.49 - 45.7) \times 2000 \times 90 = 92{,}662{,}200$
   Btu per day = 344,882,700
4. Summation of thermal requirements for electric furnaces

Duty	Btu per day
Reduction of iron of FeO	486,178,800
Reduction of silicon of SiO_2	11,700,000
Reduction of phosphorus	5,920,000
Heat to raise hot charge	344,882,700
	848,681,500

Btu per hr of electric furnaces = 35,361,729 Btu per hr

Kw (Assume 76 per cent overall efficiency, comprised of 80 per cent thermal efficiency − 4 per cent due to load utilization)

$\frac{35{,}361{,}729}{0.76 \times 3413} = 13{,}633$ kw

Kwhr, per ton of pig

$\frac{13{,}633 \times 24}{300} = 1090$ kwhr per ton pig iron

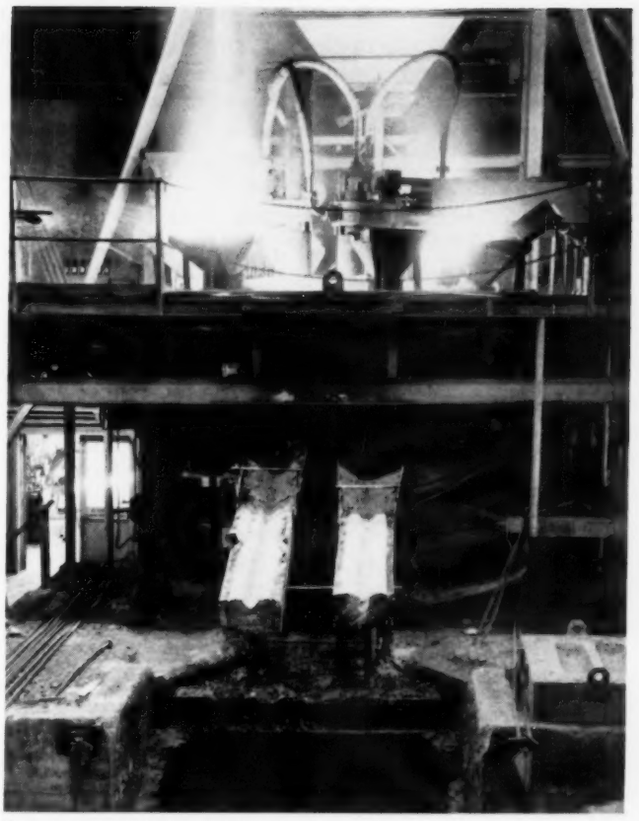


Figure 7 — At proper intervals, the 1000-kva electric furnace is tapped.

MANUFACTURING COSTS

The following Table I is a typical example of the manufacturing costs for an operation utilizing a typical purchased ore at a Great Lakes port, a purchased coal,

TABLE I

	Requirements per day	Requirements per ton pig iron	Cost per unit	Cost per ton of pig iron
1. Material requirements				
Ore (dry basis)	530 tons	1.77 tons	$11.75	$20.80
Limestone	150 tons	0.50 ton	2.00	1.00
Coal	142 tons	0.473 ton	9.00	4.26
Electrodes (15 lb per ton metal)	4,500 lb	15 lb	0.13	1.95
Misc., firebrick, mortar oxygen, other maintenance ($2.00 per ton of pig iron)				2.00
Total materials				$30.01
2. Power requirements				
Furnace	327,192 kwhr	1,090 kwhr	$ 0.006	$ 6.54
Plant (50 kwhr per ton metal)	15,000 kwhr	50 kwhr	0.006	0.30
		1,140 kwhr		$ 6.84
3. Utility requirements				
Plant water (10,000 gal per ton metal)	3,000,000 gal	10,000 gal	$ 0.01 per thousand gal	$ 0.10
Steam (20 lb per ton metal)	6,000 lb	20 lb	0.90 per thousand lb	0.02
				$ 0.12
4. Labor requirements				
Direct	1.15 man-hr		$ 3.50	$ 4.00
Indirect and supervisory	0.50 man-hr		3.00	1.50
Total labor				$ 5.50
Manufacturing cost per ton pig iron (300 ton per day)	$42.47			
Manufacturing cost per ton pig iron (600 ton per day)	41.97			
Manufacturing cost per ton pig iron (1200 ton per day)	41.47			

NOTE: Labor cost $5.50 per ton iron for 300-ton per day plant; labor cost $5.00 per ton iron for 600-ton per day plant; labor cost $4.50 per ton iron for 1200-ton per day plant.

purchased oil and power. Naturally, a captive mine operation would result in substantially lower manufacturing costs since the cost of the ore represents the major cost item. The cost of power and the cost of fuel, whether oil or natural gas, also would have an effect on the total manufacturing cost.

CAPITAL COSTS

Capital costs depend to a great extent upon the size of the plant, the location of the plant, and the quality of the coal and ore. Even to make a comparison between the blast furnace-coke plant method and the Strategic-Udy process for producing pig iron requires considerable study of each particular situation. In the case of the blast furnace-coke oven process, the minimum economical producing unit has a much greater capacity than the minimum economical producing unit of the Strategic-Udy process.

With the above limitations in mind, for a minimum economical (1500 ton per day) blast furnace plant, a capital expenditure of approximately $50.00 per "annual ton" of pig iron is required. For the by-product coke plant required for these facilities, a capital expenditure of approximately $30.00 per "annual ton" of pig iron is required.

For the minimum economical (500 ton per day) Strategic-Udy process unit, a capital expenditure of approximately $50.00 per "annual ton" of pig iron is required.

The above capital cost figures are based on a 1500-ton per day blast furnace-coke plant, whereas the Strategic-Udy process plant capital costs are based on 500-ton per day unit. These figures of course place the blast furnace at somewhat of a disadvantage since larger producing units are now becoming very common. These larger blast furnaces, of course, have a much lower capital cost per ton a year of pig iron. There is a savings both in the basic unit (the blast furnace proper) and in the auxiliaries (ore yard, power house, etc.) as the size of the plant increases to a larger-diameter blast furnace. However, with the Strategic-Udy process, the present maximum practical size of electric smelting furnace for optimum efficiency (20,000 kva) is utilized in the nominal 400 to 500-ton per day plant, therefore with an increase in capacity there is a savings only in the auxiliaries (ore yard, buildings, etc.) and not in the basic unit (the electric smelting furnace proper).

Other factors that are favorable to the blast furnace in comparative capital costs are beneficiated burden, limed sinter, higher top pressures, oxygen in the blast and other developments permitting more iron production for a given furnace size.

UNIQUE FEATURES OF THE PROCESS

The use of a rotary kiln for the reduction of iron ore has been adequately covered in the literature. The operation of the combination of a rotary kiln with a submerged arc electric furnace has also been covered in previous work.

Essentially the Strategic-Udy process is a combination of a rotary kiln and an electric furnace smelter. The significant difference between it and other processes is in the operation of the electric furnace. The submerged arc method of charging is not used. Instead a "floating charge" technique is utilized wherein the charge material slides down the sides of the furnace substantially in accordance with its angle of repose. The partially prereduced and preheated feed material is thus charged directly to the reaction zone at the electrodes making it possible to control the reduction reaction with comparative ease. Because of the close

control of the reaction zone and the method of charging, certain unique process advantages are obtained, namely:

1. No special ore preparation is required. Agglomeration, briquetting, sintering, pelletizing or nodulizing of the ore are unnecessary and not recommended. The process is designed to use fine ores, or fine concentrates (including even the very fine, iron-containing flue dust) with no pretreatment other than drying.

2. Ores contaminated with titanium, manganese and chromium, or other "impurities" from the standpoint of conventional blast furnace feed, can be employed directly. This feature of the process makes available the tremendous deposits of titaniferous magnetites on the North American continent and elsewhere for direct use as iron ores. These deposits were formerly of little if any value. In many cases these deposits are associated with present, or potential, low-cost hydroelectric power.

3. The ability to employ bituminous coal, anthracite coal, peat, lignite or coke as a combined reductant and heat-producer is a distinct advantage particularly since considerable latitude as to reductant size is possible.

4. Full advantage is taken of the hot charge to reduce materially the electric power needed.

5. Control of the carbon content of the iron is possible so that the metal ranging from pig iron of 3.5 per cent carbon to semi-steel of 0.2 per cent carbon can be readily produced for the foundry, the electric furnace and the open hearth furnace.

6. The process will make low-carbon hot metal available thus shortening the time of making a heat of steel in the electric finishing furnace. If installed in circuit with an existing open hearth, the process can make available low-carbon hot metal, thereby shortening the time of open hearth heats and reducing the amount of oxygen and iron ores necessary to remove the carbon to the desired level. Similarly, hot iron of regulated carbon content could be supplied for bessemer or oxygen-blowing processes.

7. Because of flexibility and low capital cost per ton of iron, the process could be adapted to cold metal shops where molten iron would be a great advantage.

8. The process can be developed on a unit basis to the production of 50 tons of iron per day and upward.

9. If desired, scrap can be added either in the smelting furnace or in the subsequent electric furnace.

Discussion

PRESENTED BY

V. J. NOLAN, Manager Industrial Sales, Promotion Development, National Carbon Co., Div. Union Carbide & Chemical Corp., New York, N. Y.

DAVID G. BOWSER, Assistant General Works Manager, Alloys, Interlake Iron Corp., Cleveland, Ohio

DR. MARVIN J. UDY, Vice President, Strategic-Udy Processes, Inc., Niagara Falls, N. Y.

GEORGE M. STURGEON, Project Engineer, A. E. Anderson Construction Corp., Buffalo, N. Y.

T. C. HIRST, Sogemines Consultants, Ltd., Montreal, Quebec, Canada

GEORGE CRAIG, Metallurgist, Inland Steel Co., Indiana Harbor Works, East Chicago, Ind.

ROBERT A. BLACKBURN, Sales Engineer, Koppers Co. Inc., Pittsburgh, Pa.

V. J. Nolan: The production of pig iron in the arc furnace might have a definite effect on the production cost of steelmaking and foundry products. The electric furnace manufacturers are capable of producing larger furnaces with large sized prebaked electrodes up to possibly 60 in. in diameter, and these facts coupled with the flexibility of the arc furnace present industry with a very useful process to be considered in future planning.

David G. Bowser: I would like to ask Dr. Udy if he has made calculations with respect to the total thermal efficiency of the process, in other words, Btu's per ton of iron.

Dr. Marvin J. Udy: A heat value of 18,000,000 Btu's per ton of low carbon steel was used. Note that this is not for pig iron but for low carbon steel.

George M. Sturgeon: What is the significance of the name of this process, Strategic-Udy? Is that a proper name?

Dr. Marvin J. Udy: The company, originally formed by a group of financiers and business men, had as its objective to locate and exploit ores containing strategic materials; hence the name, Strategic Materials Corp. They had a number of geologists in the field looking for various types of ores and examining various properties. Main emphasis of the search was for the so-called "strategic materials" such as manganese, chromium, nickel, etc. As a result of this search, the company acquired large, but low-grade manganese ores in New Brunswick. This is where I became associated with the company. Several processes I had developed over the years with the backing of Mr. R. O. Denman were the only ones that could economically operate on the low-grade deposits of New Brunswick. The processes are also applicable to other ores. Strategic-Udy Processes, Inc. (SUPI) and Strategic-Udy Metallurgical and Chemical Processes, Ltd. (SUMAC) are subsidiaries of Strategic Materials Corp. set up to conduct the research and development work on the processes and to demonstrate them on a prototype plant scale.

T. C. Hirst: One of the things I want to know, in the discharge from the kiln you are getting 40 or 50 per cent metallic iron. Is there a distribution factor?

Dr. Marvin J. Udy: We have not measured any distribution factors. The smaller particles grow in size through the kiln, and some may be reduced all the way through. However, we make no special effort to get them reduced all the way through because this would limit the through-put of the kiln.

T. C. Hirst: Do they reduce incidentally?

Dr. Marvin J. Udy: Yes, the smaller particles may reduce incidentally, apparently all the way through; but it is not our object to get high reduction in the kiln necessarily, because rates of reaction at 1600 C are so fast that it makes up time-wise for a lot of reduction in the kiln. We are putting 1200 C material into a 1600 C reaction zone. So our object is to get high capacity out of the kiln, taking what reduction we can get and consistently keep a high capacity, one near the blast furnace capacity.

The minimum reduction we would like is to have all iron oxide to go to FeO. Beyond that, what we get, is all to the good in some cases. In other cases, where we have to make a selective reduction, like the manganese ores, we do not want any more reduction than to FeO. Our rates of reaction in the electric furnace in this type of smelting are high so it must be recognized now as a new technique of smelting, where the hot material of 1200 C goes into the smelting zone at 1600 C. The rates of reaction are so much higher than those that have been determined at lower temperatures that you can compensate for lack of high reduction in the kiln.

T. C. Hirst: From the published literature that is coming out of Europe, the electrode consumption is generally about 20 lb per ton when the power consumption is about 2000 kwhr per ton.

For a power consumption of 1600 kwhr per ton, it seemed to me that the corresponding electrode consumption could be considerably lower than the figure you mentioned. Do you care to comment?

Dr. Marvin J. Udy: Well, I will give you our latest figures for electrode consumption. This demonstration was one that has been made because there are certain questions that we could not pin down satisfactorily for our prospective customers. In taking the starting up of this furnace and running 13 days, including the start-up, electrode consumption has been 16 lb to the ton. Now, in practice on a larger furnace I would expect it to be about 10 to 12 lb per ton.

George Craig: What is the leanest feed—the ore with the least per cent of iron—for which the process is deemed applicable? In this circumstance (the use of a low grade ore), what difficulties are anticipated with the tapping of the slag? And also, as invariably occurs when one attempts to integrate two units that have been operated separately, difficulties arise. I am sure that you anticipate a minimum of difficulty when these two units are integrated. As I understand it, they have never been operated in integrated form. You have never used your CO coming off the arc furnace as fuel for the kiln; but when you do, I wonder how you would get your distribution of kiln product around the periphery of your furnace. Will you continue to discharge at all times or will you, when you wish to maintain a certain specification of iron, have an insulated hold chamber similar to what you have been using now? And finally, the 80 per cent that you have used, you say 80 per cent efficiency for the process, do you mean 80 per cent utilization of all heat?

Robert A. Blackburn: The 80 per cent efficiency refers to the smelting furnace, the 20 per cent loss being comprised of radiation, convection and electrical losses. Furnace efficiencies of 80 per cent, I think, have been pretty well demonstrated. You can expect to achieve that in a large smelting furnace.

Dr. Marvin J. Udy: This process is one that is designed for capacity, and we are not attempting to get high reduction in the kiln.

The following figures are the summary up to date of the latest demonstration. We were asked to make two per cent carbon steel, and then we were asked to make 1½, and finally we were asked to make below one per cent for different steel people for different purposes. So we are getting information at different carbon levels. You have an apparent relationship between carbon content and the sulphur content, I will give you the relation of carbon to sulphur, an average of 17 taps carbon was 2.20 and sulphur 0.06. On the next lower level, it was 1.53 carbon and 0.09 sulphur, and the lowest was 0.89 carbon and 0.13 sulphur.

Now, we can take the sulphur lower in the smelting furnace, but when you are making this type of product, it seems to me that it is a balance between whether you do it in this smelting furnace or you allow the smelting furnace to operate at capacity all the time and remove the sulphur in the steel refining furnace. You only have to remove a minimum of carbon and sulphur. We have found on some 50-ton heats that we make in Detroit, that the carbon and sulphur both are removed with this type of steel to the desired level at about the same rate. We do not use any oxygen, and we have only small amounts of carbon and sulphur to remove to make the grade of steel required.

There is a balance between the electric smelting furnace and the kiln. With the higher rates of reaction in the electric furnace you can always balance these higher rates against the reduction in the kiln to keep a high capacity. This is an economic thing to do.

Now, to answer the other question that was asked, "Do you anticipate any difficulty when you tie the kiln and the furnace up together?" No. If you looked carefully at Figure 1 that was shown you noticed how the feed from the kiln is distributed. The feed or charge in the insulated containers is hot, entering the furnace at about 2100 F where it is rapidly reduced to metallic iron. In addition, there is some delayed reduction that takes place in the container. So we have actually more metallics going into the furnace than we have coming out of the kiln. The thing that we do want to do is keep our capacity up in the kiln and have a free-flowing charge. We do not want to form rings in the kiln. We do not allow the kiln to ring up, so we operate at the maximum temperature for any particular charge so that it does not form rings in the kiln. It is a free-flowing charge.

The electrode consumption up to date has been about 16 lb per ton of metal. We can use dust in the kiln, and our total circulating load of dust from the kilns amounts to about 1½ per cent of the charge.

Now, the loss in the kiln is very low. Our slags are running 3 per cent Fe maximum, minimum is 0.54 per cent Fe. (0.54 per cent on 2 per cent carbon iron and 3 per cent on low-carbon irons, on this particular demonstration of Group 17 ore from Mesabi, containing 10 per cent silica.)

A figure of 18,000,000 Btu's per ton of iron has been reached. That about summarizes the results to date. The kiln is running well, and the furnace is producing iron at 1089 kwhr per ton of iron. ▲

The Battle For Steel Supremacy—
The Soviet Union Leads In Raw Materials

by Alexander Gakner, East European Specialist, Division of Foreign Activities,
Bureau of Mines, United States Dept. of the Interior, Washington, D. C.

Although the U.S.S.R. will have to solve many problems first, the author believes the steel objectives of its latest Seven-Year plan can be achieved.

STEEL—one of the Soviet Union's most important and successful industries—figures prominently in Soviet economic and political planning. It receives a lion's share of the Soviet investment ruble, and it is making great strides. In 1928, the U.S.S.R.'s steel production was 8 per cent that of the United States; in 1957, it reached 50 per cent; and for several weeks, during 1958, the Russians produced steel at a rate equal to or higher than ours.

This paper concerns Soviet steel and its raw material base. Before going deeper into the subject, it will review the general economic setting in the U.S.S.R. so the Soviet steel industry can be seen in its proper perspective.

At the outset of 1959, the Soviet Union began a Seven-Year Plan for continued development of its economy. The plan was launched under the slogan—"to catch up with and to overtake the leading capitalist nations of the world, specifically the United States." If this is a Soviet challenge, it is not a new one. We have been challenged to an economic race before. Today the United States vies with the Russians for political and military prominence, but we have not become sufficiently concerned over Soviet industrial expansion to accept a challenge in this field. One reason is, of course, that in the free world we judge the effectiveness of government by the extent to which economic progress extends to the people.

We do not envy any nation which achieves success in improving the lot of its people. By any comparison of living standards, the people of the United States are so far ahead of Russia that it is understandable why many have become complacent toward the Soviet economic growth. Those who are mindful are concerned over what the U.S.S.R. intends to accomplish with its expanding industrial power. Perhaps, then, it is time for us to take a realistic view of what the rapid growth of Soviet industrial power may mean to us in the future. Some have said that while we stroll along on the road of economic progress, stopping off here and there on the way to take care of our recessions, depressions and crises, the challenger, still far behind, flexes every muscle in his body in order "to catch up and overtake the leading capitalist nation."

PRODUCTION OF RAW MATERIALS

Many economists agree that despite a 20 per cent greater population, the Soviet Union's annual industrial output is still less than half the United States'. Yet, in some fields of endeavor, the Soviets have been doing exceptionally well. For example, in 1958 (and 1958 was not a very good year for the United States), the U.S.S.R., for the first time in history, produced more coal than the United States—125,000,000 net tons more, or a total of 545,000,000 net tons.

But we should not lose sight of the fact that about one-third of this coal was brown coal and lignite; whereas, the United States output was almost all high-rank fuel. Therefore, on a heat-equivalent basis, the Soviet output was only 25,000,000 tons greater than the United States. In terms of total energy, however, the United States has a commanding lead. In 1957, for example, the

total production of energy from mineral fuels and from water power in the United States was 2.5 times that of Russia and per capita production of energy was three times as high.

In 1958, Russia produced 2,000,000 net tons more coke than the United States for a total of 56,000,000 tons; and 88,000,000 tons of usable iron ore, which surpassed our output of equivalent grade by 20,000,000 tons. Because coal is much more important to the Soviet energy supply picture and because of our growing dependence on foreign sources for iron ore, the Russians may, at least in the foreseeable future, stay ahead of us in the production of these commodities.

In 1958 the Soviet Union produced nearly 44,000,000 tons of pig iron and blast-furnace ferroalloys, compared with 51,000,000 tons in the United States. During the same year the U.S.S.R. reached a new high steel output of 60,000,000 net tons—approximating the entire European coal and steel community output of 64,300,000 tons. Meanwhile, our own steel production fell to about 85,000,000 tons. On the other hand, our total capacity was over 140,000,000 tons, while the Soviet capacity was about equal to production.

In 1959, our steel output is expected to be back at the 110,000,000 to 116,000,000 ton mark (barring strikes), while Russia's probably will reach a new high of 65,000,000 tons. Although the latter will be less than 60 per cent of our production, it could pose a serious economic threat to steel producers in western Europe and through it to the United States, depending on what the U.S.S.R. chooses to do with its steel. Should Russia decide to export large tonnages of iron and steel—and do so at cut-rate prices—it could seriously injure the economies of our NATO allies in western Europe.

PAST DEVELOPMENT TRENDS IN STEEL

Past trends of U.S.S.R. and United States steel production shed significant light on the Soviet economic threat. In the 30 years since the inception of the Five-Year Plans in 1928, Russia increased its steel output 15 fold—from less than 4,000,000 tons to over 60,000,000. It took the United States 40 years, from 1889 to 1929, to make the same advance. Because of the depression, it took us another 10 years (until 1940), to go from 60,000,000 to 65,000,000 tons while the Russians may be able to do it in one year.

It is true that having set out on their program in 1928, the Soviets had before them 30 years of advance Western technology which they borrowed very freely all through the thirties with an assist from United States engineering firms. To all industrial nations, iron and steel are the backbone of the economy; but it is more than that in the Soviet Union. Here in the United States, the rate of development of the steel industry is determined by the needs of our economy. In the U.S.S.R., the economy grows only as fast as her expanding steel industry permits. Steel is the symbol of Soviet industrial growth. It is for this reason that the production goals for steel—often with disregard to economics—are seldom permitted to fail. And when on occasion an ambitious goal for steel appeared unattainable, it was quickly revised to save face at home and abroad, particularly among the economically underdeveloped nations of the world, many of which fear communism but respect power, and which are fascinated by the rapid economic growth a Soviet-type command society apparently affords. It has been said often—and justifiably so—that in Russia steel is king and the blast furnace is queen.

German occupation of the Ukraine in 1941 cut total Soviet steel capacity and production drastically to less than 9,000,000 tons and placed an added burden on the unconquered facilities in the Urals and Asiatic parts of the country. Even before the end of World War II, the steel output in the Urals and Asiatic areas rose to 11,000,000 tons. After the war the Soviets concentrated on reconstructing steel facilities. By 1948, with the aid of equipment confiscated from East Europe, Russia's prewar production level of 20,000,000 tons had been regained. However, when the Russians produced 30,000,000 tons in 1950 and said they would double that tonnage before 1960, few people in the United States believed they could do it. The impressions of an industrially backward nation brought back to this country by the many American engineers who worked in the

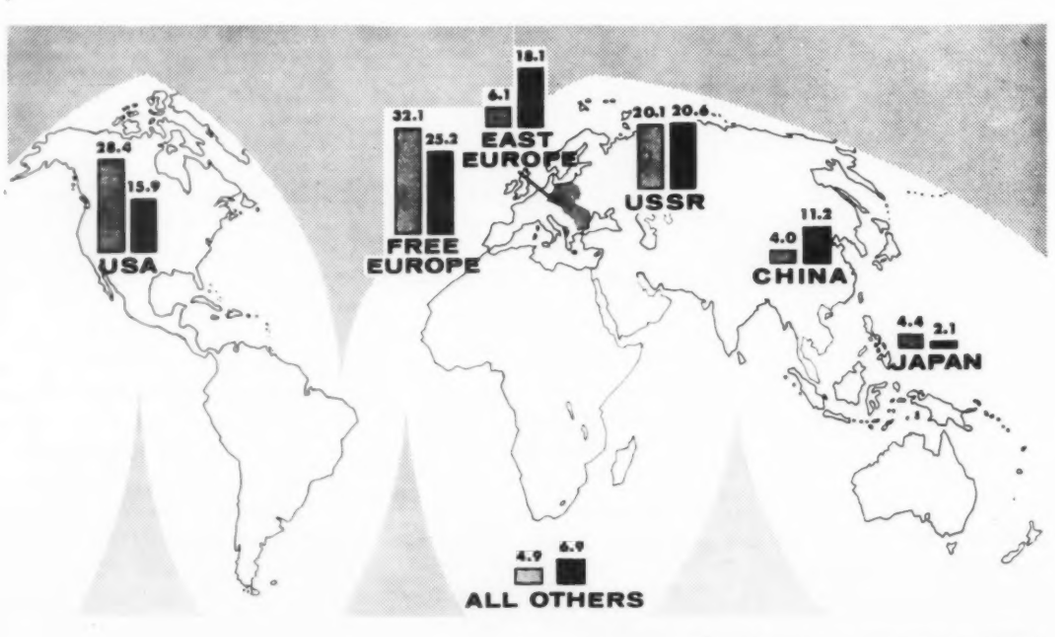


Figure 1 — The bar type charts show the percentages of the world's production of coal and steel, 2,408,000,000 and 273,000,000 metric tons respectively, produced by various countries in 1958. The black bars are coal and the cross-hatched ones are steel.

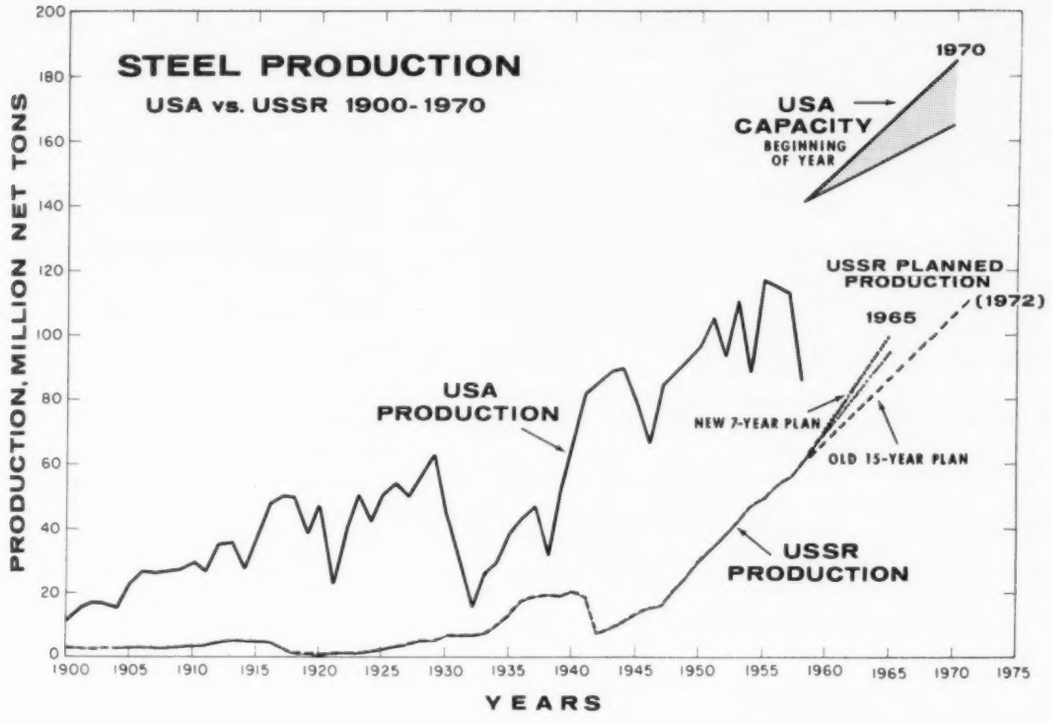


Figure 2 — This chart shows steel production in the U.S.S.R. and U.S.A. between 1900 and 1959 and the expected U.S.S.R. production through 1970.

U.S.S.R. during the thirties, coupled with the tendency to depreciate Soviet industrial growth (a tendency fashionable in this country during the late forties and early fifties), led many to believe that the Communists just did not know how to manage their abundant resources. In 1958, however, they produced 60,000,000 tons of steel, Figure 1; they expect to exceed 95,000,000 tons in 1965; and they say that they will go on from there to new record outputs until they have overtaken us in per capita production.

Consider for a while the propaganda value the Soviet Union may gain by someday becoming the world's leading producer of iron and steel. If sputniks and interplanetary travel are indicative of the country's military strength and technologic progress, then steel, to many, continues to be a symbol of economic strength. The battle for steel supremacy, therefore, is also a large part of the battle for the minds of the world's economically underdeveloped and half-starved nations.

With this in mind, it is interesting to note that construction of a 1,000,000-ton steel plant at Bhilai is playing an important role in Soviet relations with India. Steel thus is being used as an effective weapon in the cold war. Furthermore, through iron and steel, the Soviet Union has an important hold on the communist satellite nations of East Europe. In 1957, the U.S.S.R. shipped nearly 11,000,000 tons of iron ore to its East European satellites, approximately one and one-half times as much as these nations produced themselves. Moreover, the European satellites, as well as China, now depend largely on the U.S.S.R. for much of their requirements for complex metallurgical equipment.

FUTURE STEEL DEVELOPMENT TRENDS

Assuming Russia meets its production objectives, it is only natural that we should ask two important questions: (1) What will they do with the steel? (2) Do they have all the ingredients necessary to produce 95,000,000 or more tons of steel by 1965?

What will they do with that steel? This is as yet, difficult to answer. In 1958, the U.S.S.R. produced 590 lb of crude steel per capita. We produced 1000 lb per capita in 1958 and 1300 lb in 1957. By 1965, Russia plans to produce 95,000,000 tons of crude steel—a 55 per cent increase over 1958. However, allowing for Russian population growth, the per capita output will increase only 40 per cent to 830 lb. In 1939, when we produced approximately 830 lb of steel per person, our automobile industry sold over 4,000,000 vehicles. The Russians are planning to produce only 850,000 cars and trucks in 1965. The rest of the steel, they say, will go into houses and apartments, railways, pipe lines, machinery, and manufacturing plants so they may meet the goals of the Seven-Year Plan in other fields of the economy.

During the 40 years of Soviet power, the Russians have produced a total of 720,000,000 net tons of steel while we produced over 2,620,000,000 tons—more than 3½ times as much. See Figure 2. Even though some of our steel is scrapped more rapidly than in Russia, we still have about three times as much steel per capita in circulation—that is, three times as much steel in the form of machinery and equipment, plants, bridges, cars, refrigerators, washing machines and baby carriages. It will be quite a while before the Soviets can reach a similar saturation point, if that be their objective.

How about steel in foreign trade? From the instructions of the Seven-Year Plan, it appears that the U.S.S.R. will itself need all the steel it plans to produce. For purely economic or for political reasons, however, she may decide to increase exports; although at present, we know of no plan to increase the production of iron and steel for export markets. Nevertheless, with such rapidly growing output, overproduction might well occur if the steel-consuming industries fall behind. The Soviet Union is short of hard money and may decide to export surplus production. If this proves to be the case, Russia easily could dislocate established Free World

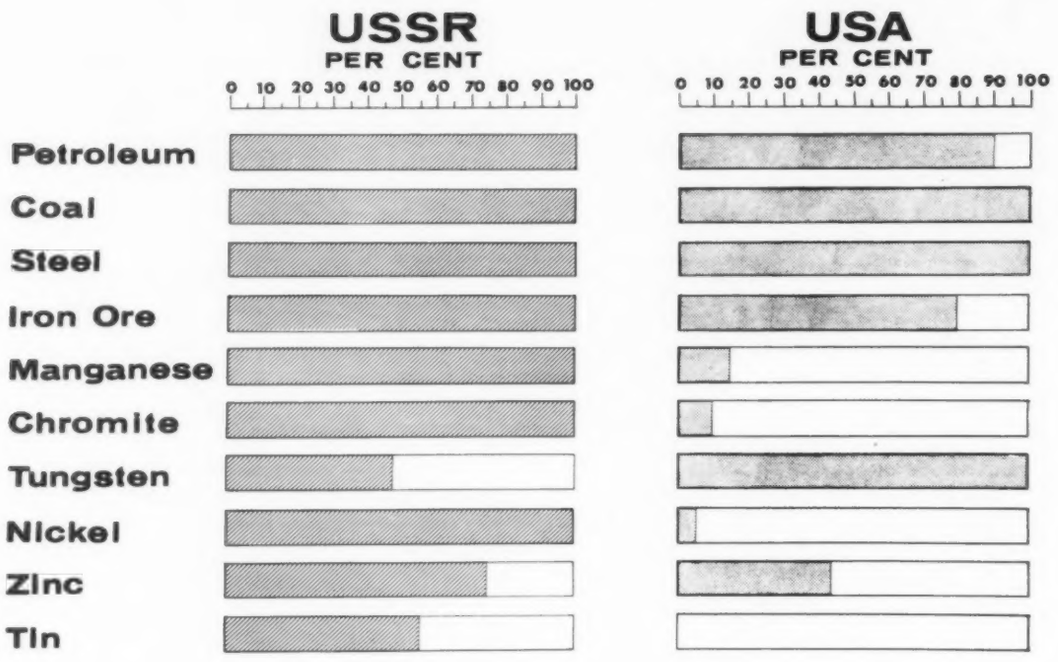


Figure 3 — These bar graphs show the per cent ratio of indigenous production to consumption for the raw materials consumed by the steel industries of the U.S.S.R. and U.S.A.

trade patterns. Those who have followed Russian foreign trade tactics in tin or aluminum over the past several years are well aware of Soviet capability to use its mineral and metal production to create market mischief. Such Soviet activities are aided by the fact that trade is a monopoly of the government.

ABUNDANT MINERAL RESOURCES

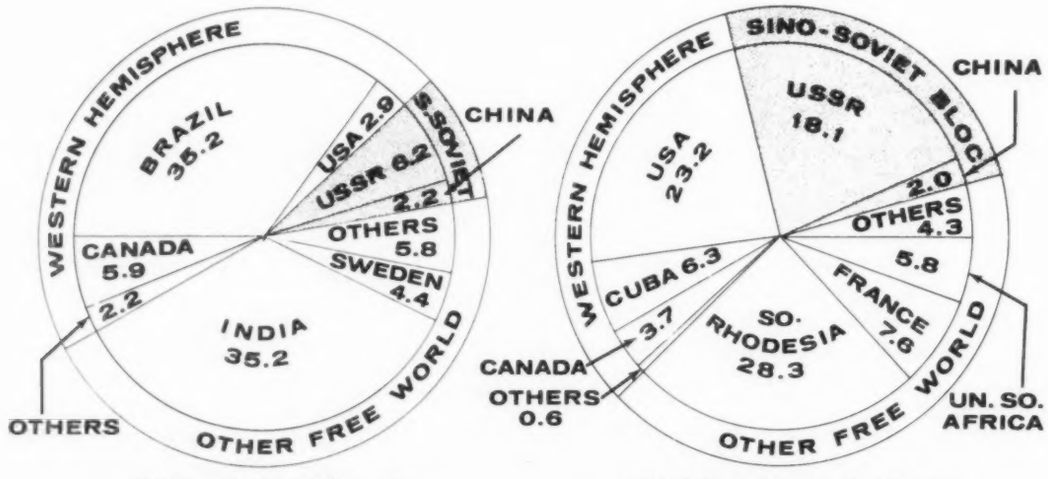
And now to our most important question: Do the Soviets possess the ingredients necessary to produce 95,000,000 tons of steel by 1965 and then go on from there to catch up with us? There are two aspects to this question: the availability and distribution of mineral resources on the one hand; and the availability of labor, investment capital and progressive technology and skill on the other.

The Soviet iron and steel industry is founded on abundant mineral resources. The U.S.S.R. is the only significant iron and steel-producing nation with large resources of the principal raw materials—iron ore, coking coal, manganese ore and chromite—within its own borders; the U.S.S.R. is self-sufficient in these, and what it lacks of the other minor ingredients, it gets from its satellites in Asia and Europe.

With its vast mineral resources, the Soviet Union has developed a huge mining industry which not only supplies its own iron and steel and other industries with their basic mineral requirements, but also provides a substantial surplus for export. Using more than 20 principal mineral commodities, and average London market quotations for December, 1957, it is estimated that in 1957 the Soviet Union accounted for one-sixth (16 per cent) by value, of the world's total mineral output. This was about half as much as the United States' share of the world's total. The United States produced about 30 per cent of the world's minerals by value. Figure 3 compares the mineral self-sufficiencies of the U.S.S.R. and U.S.A.

Russia's position as regards nickel is not quite as favorable. Reserves and production are limited and the supply situation is tight. Domestic production of molyb-

Figure 4 — Shown is the distribution of iron ore in the world.



HIGH GRADE 50% +Fe
TOTAL CONTENT
34,000,000,000 METRIC TONS

LOWER GRADE 25-50% Fe
TOTAL CONTENT
88,000,000,000 METRIC TONS

denum and tungsten is supplemented by sizable imports from Communist China and probably North Korea. The U.S.S.R. appears to be self-sufficient in vanadium, titanium and columbium; but it depends on China and Mongolia for much of its fluorspar and supplements domestic magnesite with imports from China. In general, the raw materials supply picture appears to be quite favorable. Yet, from a long range point of view, the Soviet Union will have to overcome several serious, but not insurmountable, obstacles. The more important of these will be described later.

Iron ore—As of January 1, 1956, Soviet sources estimated the total iron ore reserve of the U.S.S.R. at nearly 58,000,000,000 metric tons. This tonnage, which includes nearly 9,000,000,000 tons of titaniferous iron ore averaging less than 25 per cent iron and over 25,000,000,000 tons of taconites, they claim represents approximately one-quarter of the world reserve and is second in size only to the United States. The United States geological survey recently estimated our resources at 75,000,000,000 tons. The world's distribution of iron ore is shown in Figure 4.

Slightly less than one-quarter (22.5 per cent) of the 58,000,000,000 tons the Soviets claim, or approximately 13,000,000,000 tons, were meaured; 30 per cent, or 17,000,000,000 tons, were indicated; and the remainder, 28,000,000,000 tons, was in the inferred category. Thus, about one-half the country's 58,000,000,000-ton reserve consists of proved ore and the other half is possible ore. The proved ore reserve in Russian terminology is referred to as the "industrial" or explored reserve and forms the basis for future planning. The average iron content of the industrial reserve is 36 per cent.

On December 30, 1958, the Soviet Minister of Geology and Conservation, Peter Antropov, wrote in *Pravda* that the explored iron ore reserves of the U.S.S.R. had reached the staggering figure of 38,000,000,000 tons. He further claimed that if the Soviet Union included low-grade ores, such as those included in the United States reserve figure, the Soviet total iron ore reserve would be at least 115,000,000,000 tons. We could probably throw figures back and forth indefinitely; we could also point out that India and Brazil have enormous reserves of rich ore and that southern Rhodesia has vast low-grade resources. The fact remains, however, that Soviet iron-ore resources are large and adequate.

About 40 per cent of the contained iron is in taconites; 25 per cent in limonites; and about 10 per cent each in magnetites, hematites and titanomagnetites.

Coking coal—Less than a year ago, Russia released new estimates of its coal reserve, listing the total resources of the Soviet Union, including anthracite, bituminous and brown coals, at nearly 8,700,000,000,000 metric tons, or more than one-half of the world total; this is also five times greater than our estimated coal reserves. Upon closer examination of the Soviet figures, however, we find that nearly 60 per cent of the coal resources are located in permafrost areas of Siberia, north of the 60th parallel, where freezing temperatures prevail through most of the year. Furthermore, over half the reserve has an overburden exceeding 2000 ft, whereas, in the United States 97 per cent of the reserve has an overburden of less than 2000 ft. By interpolating the Soviet figures, one arrives at the conclusion that by American standards, the Soviet coal reserve is not larger than ours. In fact, the same Soviet source recognizes that the commercially exploitable coal reserves are, at present, only about 1,000,000,000,000 metric tons, or slightly more than half the United States figure. This ratio, however, may be improved substantially in view of the high recovery practiced in Soviet coal mining as compared with the heavy losses in United States coal mines. Figure 5 shows the world's distribution of coal.

The total reserve of straight coking coals at the principal coal basins in the U.S.S.R. is about 60,000,000,000 tons; however, only one-third of this tonnage can be mined economically today. On the other hand, the Russians claim that over 20 per cent of the total coal, when properly blended, is suitable for producing coke. Whatever figure we use, it is apparent that, as in the case of iron ore, the Soviet coking coal reserves are large. And with the high coal recovery practiced in the Soviet Union, these reserves are adequate to satisfy all anticipated needs.

Manganese ore and chromite—The Soviet Union boasts the world's largest reserves of both manganese ore and chromite, but for the past 20 years it has published little data on its resources to substantiate this claim. Pre-World War II figures credit the U.S.S.R. with more than 800,000,000 tons of commercial-grade manganese ore; while reserves of chromite, mostly refractory grade, were reported in excess of 30,000,000 metric tons. It is likely that the known reserves of both have been enlarged in recent years through extensive exploration.

In any event, the reserves are large and adequate for substantial growth. Production of manganese ore (nearly 5,000,000 tons annually), and chromite (over 800,000 tons annually), satisfies all domestic needs and provides for substantial exports. In contrast, the United States in 1957 produced less than one-sixth the manganese ore and less than one-tenth the chromite it consumed during that year.

Figure 5 — Illustrated is the distribution of the world's coal resources.

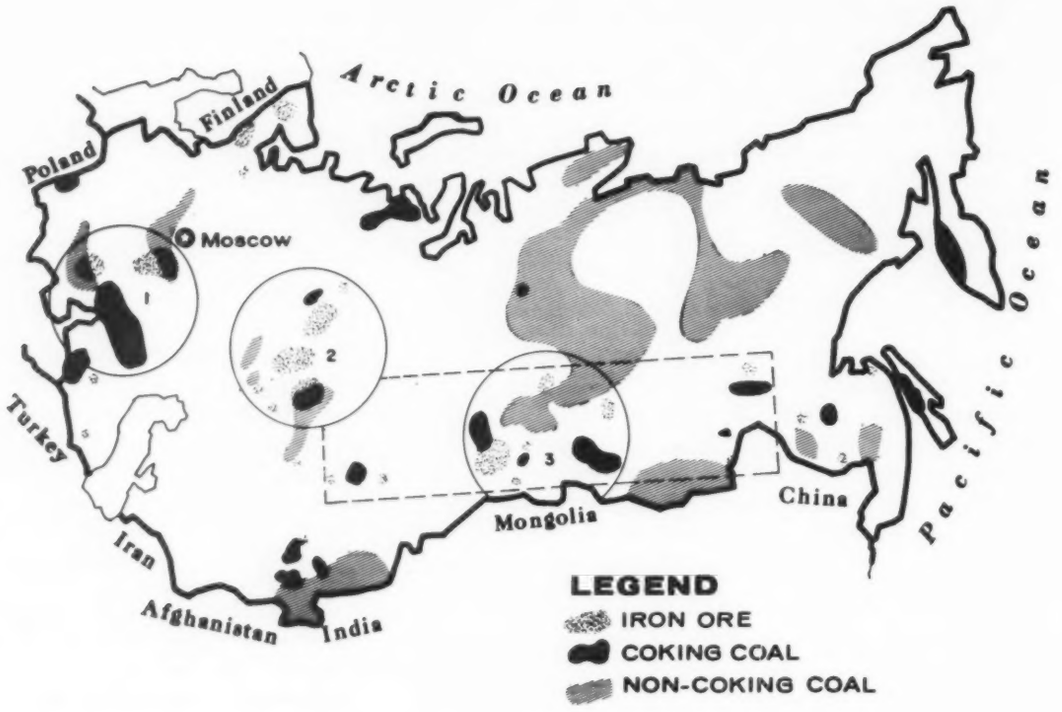


Figure 6 — This map shows the major deposits of iron ore and coking coal in the U.S.S.R.

Scrap—Because of many reasons, the most important of which are the small inventory of potentially recoverable iron and steel and the rapid growth of the industry, the U.S.S.R. consumption of scrap is relatively less than in the United States and, therefore, its pig iron-to-crude steel production ratio is higher.

For ten years prior to World War II, the pig iron-to-steel ratio in the U.S.S.R. averaged 0.90. The war improved the scrap supply, but by 1950–51 the country's scrap picture deteriorated. The pig iron-to-steel ratio increased from 0.70 in 1950 to 0.73 in 1955 and in the immediate future is expected to continue its climb because:

1. More modern fabricating techniques reduce the annual "prompt industrial scrap" supply.
2. The introduction of new rolling and casting methods is expected to decrease the annual availability of home (circulating) scrap.
3. Improved machinery and equipment maintenance practices further retard the rate of the return of old scrap.

In contrast to the Soviet ratio of 0.73, the pig iron-to-crude-steel ratio of the United States has averaged 0.66 during the past 10 years.

Composite picture—We have given the credit side of the Soviet supply picture of the principal raw materials. Let us now examine the other side of the coin. Here, I will make it clear that I personally do not consider any of the major problems which the Soviet iron and steel industry is facing as insurmountable. It will mean greater effort and smaller returns per investment ruble, but it does not preclude the goals being reached.

Approximately three-quarters of the population live in the Ural and European parts of the U.S.S.R. These areas also account for three-fourths of the nation's industrial output. However, over 90 per cent of the total coal resources, including over two-thirds of the coking coal reserves, are found east of the Ural Mountains in Asiatic Russia. This situation poses serious problems in logistics for future industrial growth

Figure 6 geographically locates iron ore and coal in the U.S.S.R.

The Donets Basin, which accounts for more than 50 per cent of the country's coke output, yields high-sulphur coke. The same is true of the Kizel Basin, the only local source of coking coals in the Urals. In fact, the average sulphur content of all metallurgical coke used in the U.S.S.R. today is 1¼ per cent. Furthermore, the coals in any one basin are not complementary, and any blending that is done must be done with coals from different basins. As a result, large tonnages of coal are delivered annually from Asian coal basins to the Urals and even to European consuming centers over 2000 miles away.

The geographical distribution of the iron ore resources in relation to the industrial centers is much more favorable, yet not without some problems. Because a large share of the country's direct shipping ore is found near Krivoi Rog, that area has consistently contributed more than half the nation's usable iron ore output to meet domestic needs as well as exports. Although the high-grade reserves of Krivoi Rog are still large, it has become necessary to go very deep to maintain production. Mining operations are further handicapped by a serious ground water problem. As a result, the production of concentrates from taconites found elsewhere can now favorably compete with high-grade Krivoi Rog ores.

In 1940, 82 per cent of the total ore mined in the U.S.S.R. was of direct shipping grade; the average iron content was 55 per cent and the crude-to-usable ore ratio was 1.05. By 1955, only 58 per cent of the total ore mined was of direct shipping grade as the average iron content had dropped more than 7 points to 47 per cent and the crude-to-usable ore ratio rose to 1.2; the Russians expect it to reach 1.4 in 1960 and 1.8 by 1970.

This does not mean that the Soviet iron ore industry is doomed, but it does mean that increasing proportions of the investment ruble will have to go into the construction of beneficiation plants as well as mine expansion.

The average shipping distances for coal and iron ore, practically all by rail, are greater in the U.S.S.R. than in the United States. This creates logistics problems. An example is in the Leningrad industrial district. The nearest iron ore is 300 miles to the north, and the nearest coking coal is over 1000 miles to the east. Because of these distances, the iron and steel industry of the Leningrad area never developed sufficiently to satisfy all local needs, and crude and semi-finished steel are shipped into the area from the Ukraine and the Urals. Simultaneously, the Leningrad area generates a surplus of scrap which is returned to the steel plants in the South and in the Urals.

To alleviate these problems in the future and to utilize its resources more fully and efficiently, the Soviet Union plans to expand the Cherepovets plant near Leningrad and adopt it to greater use of scrap, and to develop a third metallurgical base in Asia. This base will stretch from the Karaganda Coal Basin in the West to Lake Baikal in the East. Within this region there are several locations where both coal and iron ore can be produced by strip mining and which appear to be favorable for large scale metallurgical development. Large undeveloped hydroelectric sites also offer excellent opportunities for cheap power needed for electric furnace steel production and electric blast furnaces. However, in view of prevailing conditions in the region, the expansion plans must also provide for developing transportation facilities, a steady supply of skilled labor, a steel-consuming industrial complex and a market for finished steel products. These are formidable obstacles to overcome in that vast but sparsely populated part of the country.

Labor—Labor supply also is a growing problem in the U.S.S.R. Collectivization and gradual mechanization of the Soviet farm system formerly freed millions of people for expanding industry. Every hand was put to work. As long as the labor market was amply supplied, new and old plants alike were kept in the production line.

World War II changed the picture considerably. Millions of people were killed and crippled on the frontiers and more died in the hinterlands from disease and starvation. In addition, the decreased birth rate during five years of war and the need to maintain a large army after the war left the country short of labor to meet its ambitious economic expansion plans. Farm and city alike felt the labor pinch. As the U.S.S.R. imported labor brigades from Bulgaria and elsewhere in East Europe, there was actually a reversal of the labor movement from the city to the farm to meet the needs of the "Virgin Land" program. The Soviet Union can no longer afford to waste its labor force in old and obsolete plants and farms. The questions of labor efficiency and production costs—two long neglected issues in the Soviet Union—have been brought back into focus. Obsolete plants are gradually being replaced as investment resources are made available.

Investment capital—As time goes on, the Soviet investment ruble is bringing diminishing direct returns in production. This results from the following factors:

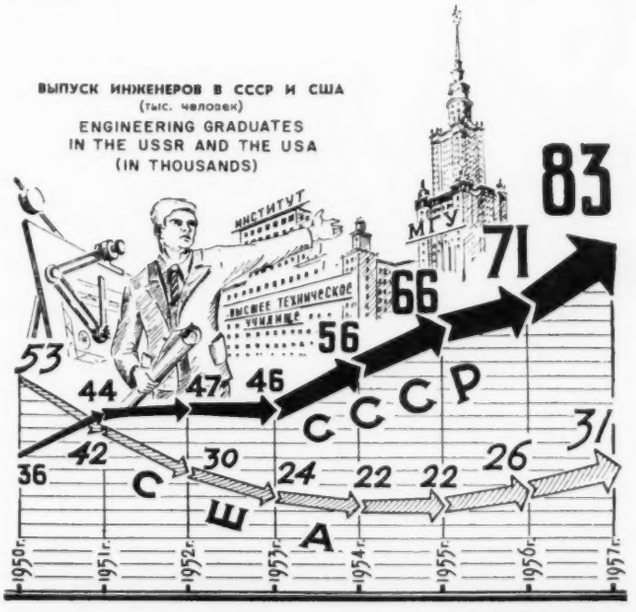
1. Labor costs in mining, due to wage increases which reflect the growing scarcity of labor, have advanced more rapidly than labor productivity.
2. The decreasing quality of the country's mineral resources requires greater effort in the preparation of the raw materials.
3. Increasing amounts of money (that is, investment resources), must be spent to replace obsolete equipment and to take care of normal depreciation.

During the next seven years, the U.S.S.R. plans to invest 100,000,000,000 rubles in the ferrous metallurgy industry. During the past seven years only 42,000,000,000 rubles were invested. Using steel production as an index of the country's steel capacity, we find the gain in capacity during the past seven years was about 26,000,000 net tons. Similarly, the planned increase in capacity during the next seven years will be 35,000,000 tons. Thus, by increasing capital expenditures 2.4 times, Russia's net gain in capacity will increase only 1.4 times. This is a gain of over 70 per cent in the unit cost of steel plant from 1650 rubles per annual ton of steel capacity during the past seven years to 2850 rubles during the next seven years.

Technical progress—Whether the Russian foresight was as good or better than our hindsight we do not know. The Soviets must have anticipated the tight labor situation and the diminishing returns on their investment ruble. They also must have realized that in order to maintain a high rate of industrial growth, one of their best bets was to emphasize technical progress. Early in the post World War II period, they set out on a technical education expansion program which is unsurpassed in the history of mankind. We do not expect that the Soviet authorities had much of a problem convincing the citizenry of the merits of education, particularly with the material advantages enjoyed by supervisors as compared with the supervised in the U.S.S.R. The results of the Soviet technical education drive are reflected in Figure 7 which presents a cartoon that appeared recently in *Pravda*.

In 1955, nearly 12,000 Soviet engineers were graduated in fields related to the mineral industries: mining,

Figure 7 — This cartoon, which recently appeared in *Pravda* shows the results of the U.S.S.R's technical education drive. The top curve is U.S.S.R. and the bottom the U.S.A.



PRAVDA, NOV. 2, 1958

geology and metallurgy. This represented about one-fifth total engineering graduates in Russia that year and was nine times as many as were graduated from United States colleges and universities with degrees in mining, geology and metallurgy in 1955. Russia has at least 12 schools where a student can receive a degree in a highly specialized branch of ferrous metallurgy. He can major in blast furnace design, construction of open hearth furnaces, operation of rolling mills or in the physical metallurgy of steel.

An army of Russian geologists was trained and dispatched to the field to uncover and explore the country's vast mineral resources. Some of the results of their work have been published. There is, for example, a 560-page book describing in great detail practically every known iron ore deposit in the U.S.S.R. Similar mineral reserve studies, we understand, are being readied for other mineral commodities as well.

While the Soviet geologist was exploring for raw materials, the Soviet metallurgist, who until the early postwar years depended heavily on borrowed technology, started to contribute a great deal of his own to the science of metallurgy. He since has shown considerable ingenuity. In 1928, Soviet blast furnaces were quite inefficient. About 60 cu ft of furnace volume was required to produce a ton of pig iron per day. Through borrowed technology, Russian metallurgists reduced that figure to 37 cu ft in 1938. Practice remained at this level all through the war years. In 1946, progress was resumed and today an average of 25.5 cu ft of blast furnace volume produces a ton of pig iron. If the Russian claims are accurate, they are utilizing their blast furnace volume about 20 per cent better than we are. This has been achieved mostly by sintering the ore and preparation of self-fluxing blast furnace feed. Carefully sized feed and the use of top pressure have improved the flow of gases, decreasing iron reduction time and cutting flue dust losses to a very low level. Thus, while the total blast furnace volume has increased four times in the 30 years since 1928, actual production of pig iron has increased about 11 times.

A similar rate of technical progress was achieved in open hearth practice which accounts for 88 per cent of the total steel output. By cutting the hot and cold downtime, Russian metallurgists by 1949 attained our then current open hearth performance of approximately 21 net tons of steel per 1000 sq ft per hr of operating time. Since 1949, the Russians made further cuts in hot and cold downtime by increasing the use of top- and lance-injected oxygen-enriched flames. In 1955, they reported an average yield of 27.5 net tons of steel per 1000 sq ft of hearth area per hr, with some of the larger furnaces yielding as much as 32.5 net tons. This, we believe compares favorably with our modern open hearth practices.

According to various groups that have visited the U.S.S.R. in recent years and from published Russian material, it is evident that the Soviets have an extensive research program reaching into every facet of metallurgy. The general feeling is that in some important phases the Soviets are ahead of us. However, they have neglected other branches considered equally important by U. S. metallurgists. If it were possible to find a common denominator, the total volume of metallurgical research probably is about equal in the U.S.A. and the U.S.S.R.

Summarizing, we believe that the circumstances are in favor of the Russians reaching their steel objectives. We should have no illusions about their ability eventually to produce 95,000,000 tons of steel a year. Considering, however, that the large steel expansion program is only one part of a most ambitious Seven-Year Plan, it will call for herculean effort and further postponement of the more abundant life for the average Russian if the objective is to be met on the stroke of midnight, December 31, 1965.

Today, we find ourselves more and more frequently counteracting various Russian moves and it is as if they are indirectly dictating our lives. Under such circumstances, it is most difficult to say what is good for us and this presentation is just an effort to give an unbiased picture of the current steel and raw material scene in the U.S.S.R.

But in conclusion, we ask: Should we accept the Soviet challenge to a race in steel production? Should we send all our children to technical schools and become a nation of engineers and metallurgists to learn how to make swords? Or, is it just as important that some of our children also become social scientists to teach future generations how to beat swords into ploughshares and to teach them how to live with each other and with themselves?

Russia is today on the threshold of great industrial expansion and has rich virgin mineral wealth to support it. On the other hand, the United States already has a pre-eminent position in industrial world power, but our mineral base is showing signs of depletion and old age.

Who is to say exactly how much we should spend for mineral exploration at home to prolong our basic strength and to assure this country of as broad a mineral base as possible? When cheaper raw materials can be had from across the seven seas and when technologists develop superior substitutes for the raw materials we lack, need we be unduly concerned over our vanishing mineral resources? How tight do we pull in our belts if there is never to be another emergency? Another emergency! What are the odds for eternal peace today? ▲

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Continuous Annealing In Molten Sodium

by J. D. Keller, Partner, Associated Engineers, Pittsburgh, Pa.

The high coefficient of molten sodium as a heat transfer medium makes possible continuous annealing of strip in 30 ft of travel at the production rate given by a conventional annealer with 2100 ft strip travel.

THE designers of typical present-day continuous annealing furnaces for sheet-strip deserve great credit for successful large-scale engineering, for these furnaces are literally the size of a house, or larger—about 65 ft high x 100 ft long.

The exterior of such a furnace is shown in Figure 1, and the "works" of it are sketched diagrammatically in Figure 2. (It makes no difference which particular furnace is the one shown in Figure 1, for they are all essentially alike.) Such an annealing line including loopers and coilers is stated to cost between $4,000,000 and $7,000,000; all this (with numerous other disadvantages) for an output of only about 30 tons an hour. Yet numbers of such furnaces have been and still are being installed. Why?

The answer seems to be that this was the obvious way to anneal strip continuously; the first few furnaces operated successfully were of this type, and since no one then had anything better to offer, inertia prevailed, and each succeeding furnace was built the same way as its predecessors.

Not that there was any lack of continuing efforts to find something better. For example, in a paper [1]* by Clarence E. Peck published in 1954, 10 different annealing methods, either in use or under consideration, were described.

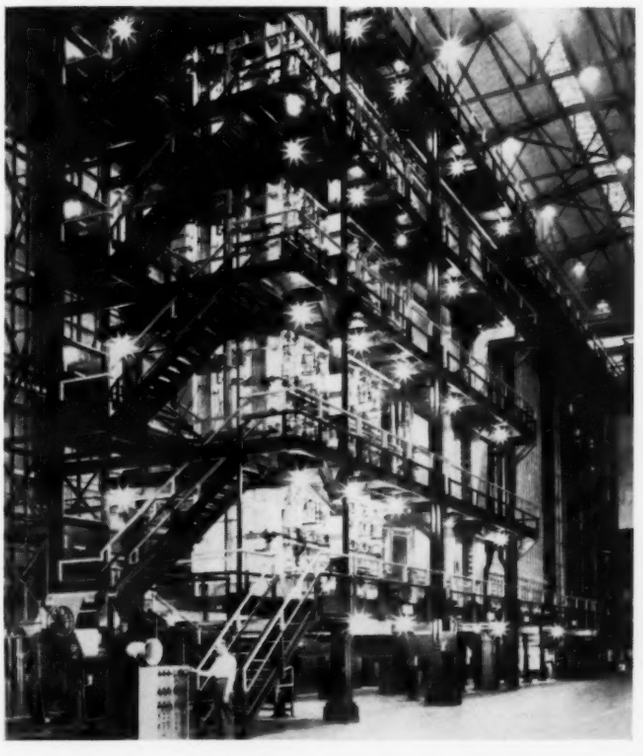
Two of the proposed methods showed real promise as regards the heating part of the cycle, though they required the use of electric energy which is relatively expensive compared with gas fuel. The trouble is that the cooling part of the continuous annealing cycle is much more difficult than the heating—it will be noticed in Figure 2 that four times as great a length of strip travel is required for cooling as for heating—and none of the proposed methods offered any considerable improvement in the cooling.

Such was the state of the art about seven years ago, when development of the sodium-bath annealer was begun. What led to the choice of that metal as the heating and cooling medium was its extremely high heat-transferring ability; though other advantages appeared on further study. A comparison of the coefficients of heat transfer for the different methods is enlightening. In the radiant-tube heating section of the conventional continuous annealer, because the smooth bright surface of the strip reflects instead of absorbing most of the heat radiated to it, the coefficient is only of the order of 10 Btu per sq ft per hr per degree F, while in the cooling section where the radiating temperature is lower, it is much less than 10. In a salt bath, the coefficient is probably about 100. Contrasted with these is the extremely high rate of about 1400 Btu per sq ft per hr per degree F even in stagnant sodium, which increases to at least 6000 at a strip speed of 1000 fpm and goes still higher as the strip speed is further increased.

This very rapid heat transfer effected by using sodium has a number of important advantages when combined with the principle of reversing the travel of the strip upon itself after it has reached the annealing temperature, and causing it to travel back in close proximity to the incoming strip through zones of decreasing temperature. The arrangement of the annealer embodying this principle is shown diagrammatically in Figure 3.

By this method, it is possible with a total strip travel in the sodium bath of about 30 ft to anneal strip at the same or a higher production rate than in a conventional continuous strip annealer of the radiant tube type with about 2100 ft of strip travel in the furnace. Conse-

Figure 1 — Although the conventional continuous annealing furnace costs between $4,000,000 and $7,000,000, its output may be only about 30 tphr.



* Numbers in parentheses refer to Bibliography at end of text.

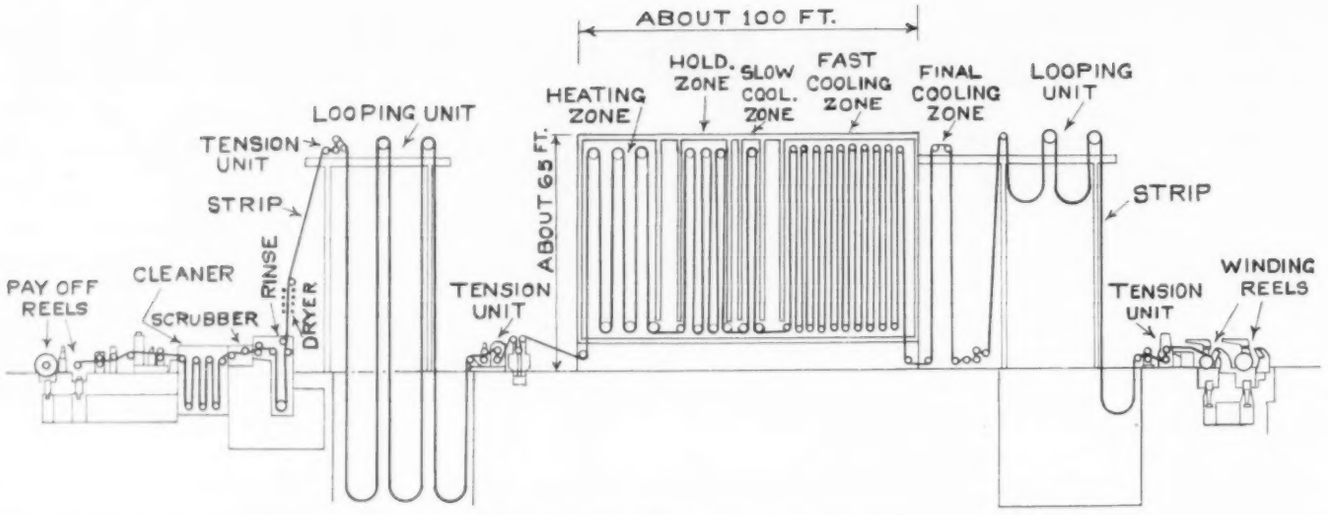


Figure 2 — This is a pass-line diagram of the typical continuous annealing furnace.

quently, the size of the unit can be very greatly reduced as previously stated. For example, an annealer to operate at a strip speed of 1000 fpm, processing tinplate stock 0.010 in. thick at the rate of over 30 tons an hour, need not be more than about 15 ft high, about 6 ft long, and probably 4 ft wide for 32-in. strip width. At a conservative estimate, the cost of such a unit with the required auxiliary equipment would be less than $\frac{1}{10}$ of that of a conventional continuous annealing line of equal capacity.

Part of this economy of space results from the fact that both heating and cooling are effected in the same space, due to the close proximity of the two adjacent strands of strip moving in opposite directions.

At the same time, this principle results in a great saving of fuel. The strip enters at room temperature, is heated to about 1330 F for annealing (in the case of low carbon strip), and then is cooled to about 300 F before leaving the sodium bath, giving up its heat to the sodium which transfers it to the incoming strand. Thus, by far the greater part of the heat is recovered; all that is lost is that corresponding to the difference between 60 and 300 F, or about 31 Btu per lb of strip, as compared to the difference between 60 and 1330 F, or about 199 Btu per lb in the conventional furnace where none of the heat can be recovered during the cooling of the strip.

In addition, because of the small superficial area and much lower interior temperature, the wall loss is insignificant compared to that of conventional annealers, in which, as operators have stated to the author, the heat emitted from the walls is so great that they find it difficult to get men to work around these furnaces.

For these reasons, the fuel consumption of the sodium annealer should not exceed about 16 per cent of that of conventional annealers, as a reasonable estimate.

Because the maximum temperature of the sodium need be only about 50 F higher than the optimum annealing temperature, and because the sodium does not harm but protects the surface of the strip, the motion can be stopped with the strip in the bath. In conventional annealers, of course, the strip must not stop while in the furnace; hence in order to permit welding the front end of the strip from a new coil to the rear end of the strip going through the furnace, a looper must be provided at the entrance end; and to permit stopping the front end of the strip for starting its recoiling, another looper is provided at the exit end as shown in Figure 2. In the sodium annealer, these very expensive looping towers and their pits can be eliminated.

Another important advantage of the small compact sodium annealer is the avoidance of "atmosphere collapse" which is so troublesome in conventional annealers. This phenomenon results from change of average temperature, especially in the cooling chambers, when for operating reasons the strip is slowed down to, say, 50 per cent of maximum speed. The corresponding contraction of the volume of the gas in these huge chambers occurs so quickly that it is beyond the capacity of the de-ox gas generators to cope with it; the pressure drops below atmospheric, and air is sucked into the chambers, producing danger of explosion and certainty of bluing the surface of the thousands of feet of strip contained therein. In the sodium annealer, on the contrary, the volume of protective gas above the sodium is so small and the temperature so constant that no such trouble can occur.

There is no absolute necessity for the strip to emerge into a gas filled space at the top of the right leg of the U as it is shown in Figure 3. Instead, the left leg could be made a little higher, the sodium level raised, and the top rolls run submerged in the sodium. However, in order to avoid any possibility of erosion due to cavitation in this high-temperature part of the liquid, it is thought preferable to have these top rolls run in gas rather than in the sodium.

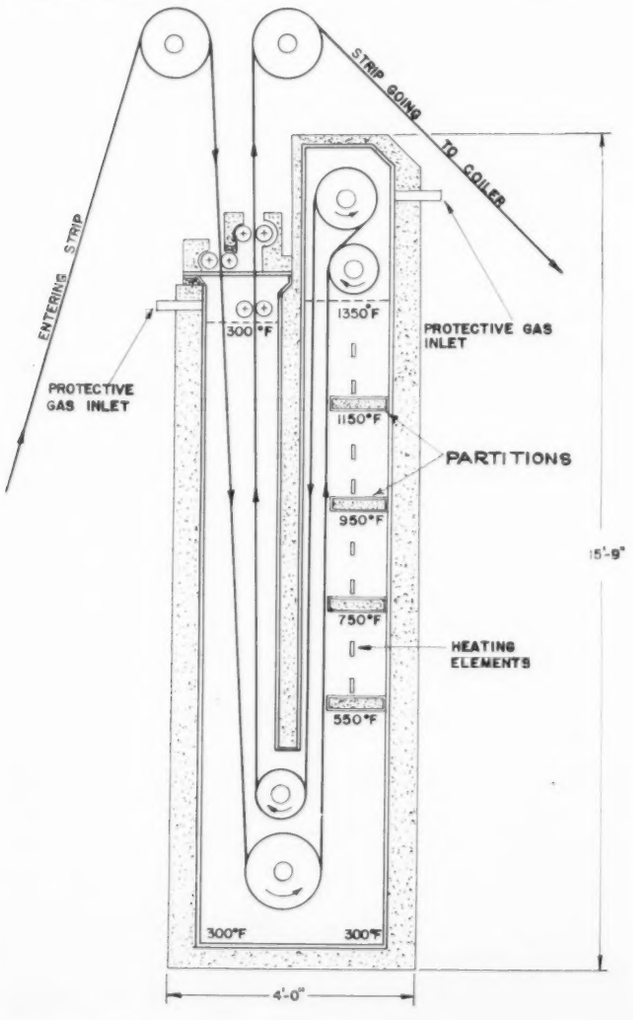
The insulated partitions shown in the right leg of the U-shaped sodium container in Figure 3 have two objects. The first is to maintain the temperature gradients approximately as noted in that Figure. Although with the hottest zones at the top as shown, there is no tendency for up and down circulation of the sodium due to natural convection currents, nevertheless there is a tendency for the temperatures to equalize or the gradient to be reduced due to the extremely high thermal conductivity of the sodium. The insulated partitions can be used to prevent this. Second, there is a certain amount of "viscous drag" of the strip on the liquid which tends to carry a film of it up with the rising strand and down with the descending strand of strip

Sodium has very low viscosity; at 300 F its viscosity is about 50 per cent and at 1300 F only about 18 per cent of the viscosity of water at room temperature. [2] Also, in the space between the closely adjacent strands the motions neutralize each other, resulting in practically no net transfer of liquid. On the outer sides of the strands, the edges of the partitions, even though they do not touch the strip, are expected to greatly reduce the velocity and minimize the thickness of liquid film carried along with the strip.

Uniformity of temperature across the width of the strip should be another important advantage of the sodium annealer. In the heating section of the conventional continuous annealers, with radiant tubes extending horizontally across the furnace, the edges of the strip are unavoidably heated faster than the middle part. In the cooling section, the edges cool faster than the middle; this differential cooling is accentuated by the convection currents in these tall furnaces. Attempts have been made to correct this by using water-cooling pipes formed in V-shape with the point of the V toward the end from which the strip is moving, but without much success. The author has seen the strip coming out of these furnaces in such a severely buckled condition that it could not be made to track straight, and the motion had to be stopped at short intervals.

In the sodium annealer, the conductivity is so extremely high that practically no lateral variation of temperature can exist in the bath, hence the strip is heated and cooled uniformly across its width.

Figure 3 — This continuous annealer uses sodium as a heat transfer medium.



PROBLEMS OF DESIGN AND OPERATION

Since this is an engineering paper rather than a promotional essay, it is the author's desire in what follows to be entirely frank in discussing possible drawbacks or troubles, even at the risk of making them seem more serious than they really are.

The most difficult problem that had to be solved in developing the sodium annealer was that of reducing to a minimum the drag-out of sodium on the strip. Below about 900 F, normal cold-reduced low-carbon strip is not wetted by liquid sodium, but above that temperature wetting occurs, and the strip does not de-wet when cooled to lower temperatures. In the testing work at Chem-Metals Laboratory, numbers of devices were tried for removing the adhering sodium film, such as scrapers of various forms, wiping pads, squeegee rolls, nylon brushes and others. Finally, by the use of rotating brushes of fine nickel-silver wire, moving opposite to the strip motion, wiping was effected which was sufficiently good to show that in a full-scale unit the drag-out could be kept well within the economic limit.

What little sodium remains on the strip wiped in this manner is in the form of evenly distributed impalpable powder. When it emerges into the air, this finely divided sodium immediately oxidizes, without any visible or audible action. When the strip is then passed briefly through warm water, the sodium oxide immediately washes off, and the sensible heat remaining in the strip as it emerges from the dip at once dries off any water remaining on it, leaving the strip surface entirely clean.

Another important problem is that of minimizing the drag-*in* of oxygen on the strip as it enters the unit. One of the purposes of the left leg of the U-shaped container (referring to Figure 3) in which little heating is done, is to condition the strip surface by getting rid of the gas film clinging to it. The nitrogen of the air film which enters on the strip is easily displaced by the sodium, but the oxygen reacts with the sodium, forming Na_2O. To minimize the drag-in, it is planned to use rubber squeegee rolls at the place where the strip enters the container. The strip is cold at this point, hence the rubber will not be harmed by too high a temperature. Practically all but the occluded gas film thus can be removed. And since this film, which is held to the strip surface by molecular attraction, is only a few molecules thick, the build-up of sodium oxide resulting from the occluded oxygen should be very slow.

One objection that has been raised to the use of rubber-covered rolls is possible cutting of the same by sharp turned-over edges of the strip which sometimes are produced by improper setting of the side-trimming shear knives. However, tougher kinds of rubber are being produced right along, and it is believed that this objection will not be serious.

If the slow formation of sodium oxide can be confined to the conditioning side of the U, it is possible that the strip leaving the bath will carry out with it, along with the slight amount of sodium powder, as much oxide as is formed by the incoming occluded oxygen. This possibility is not being counted on, however, and since the oxide suspended in the sodium is quite

undesirable, means will be provided for removing it continuously. Fortunately the technique for doing this has already been well worked out by the Atomic Energy Commission; the sodium is circulated, cooled to just about the fusion point (which is 208 F), passed at very low velocity through filters of stainless steel wool, and returned to the chamber. The filters are duplex, to permit removing the oxide from them. Even more effective porous filters have recently been developed.

It is felt that in order to insure proper tracking of the strip in the bath, the shafts carrying the submerged rolls (Figure 3) should be adjustable as to both horizontal and vertical alinement. Arrangements could be made to effect this adjustment without having the shafts project through the sides of the sodium container, but there is the additional consideration that it may be desirable to supply a regulated amount of torque to these shafts in order to avoid any possibility of excessive tension in the strip at the top of the right leg of the U where it reaches 1330 F. For these reasons, the preferred design calls for carrying the two shafts out through the sides of the container at the bottom of the U, and much mental tribulation was undergone when the development was started, because at that time there was no satisfactory seal against leakage of sodium around a rotating shaft.

The solution was very simple. It was independently suggested by the author's associate, Professor Trinks, and we later learned that at or shortly before that time the same idea had occurred to engineers of a large electrical manufacturer.[3] The solution consists of controlled freezing of the sodium in a sleeve around the shaft at the place where the sealing is to be effected. The initial wear of this very soft metal by the friction of the shaft produces a clearance which is sufficient to permit free rotation but not to allow leakage of the adjacent liquid sodium.

Also at that time, there was no satisfactory pump for liquid sodium, such as might be needed for passing the liquid continuously through filters. Practicable pumps of both the mechanical and the electromagnetic types have since been put on the market. However, it now seems probable that no pump will be needed for the sodium annealer. The liquid can be circulated and the container drained or refilled by alternate raising and lowering of auxiliary sodium containers, with suitable valving.

Provision must also be made for rethreading in case breakage of the strip occurs within the sodium container. Sheaves can be mounted loosely on the shafts at each end of the drums or rollers, with nichrome wires always in place in the grooves of the sheaves, extending from the entrance to the exit end of the strip path. Ordinarily the sheaves will remain stationary. When strip breakage occurs, the front end of the rear part of the strip will be sheared square and its front corners will be attached to the nichrome wires which will then be pulled through the unit, carrying the strip with them to the exit end.

The material for containing the sodium presents no problem. Stainless steel of 18–8 (No. 304) or 25–20 (No. 310) grades have been found to be completely free from attack by sodium, up to and above the highest temperatures used in the sodium annealer. The welds must of course be carefully made and free from pin-

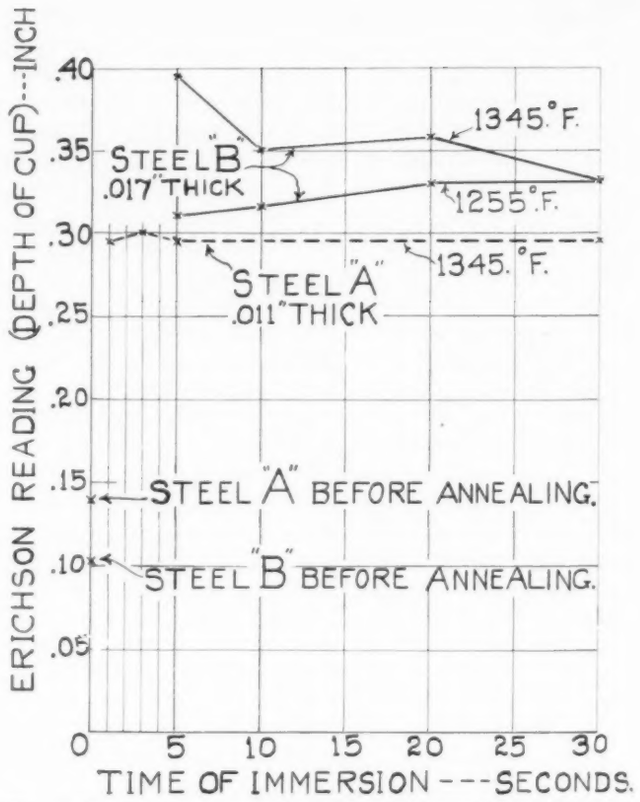


Figure 4 — These curves show the cold-forming properties of two different kinds and thicknesses of cold-reduced low-carbon steel strip before and after immersion in a hot sodium bath at the temperatures specified.

holes, inclusions or porosity. The interior surfaces of the container become bright because the sodium removes the oxide, but no attack on the metal itself occurs.

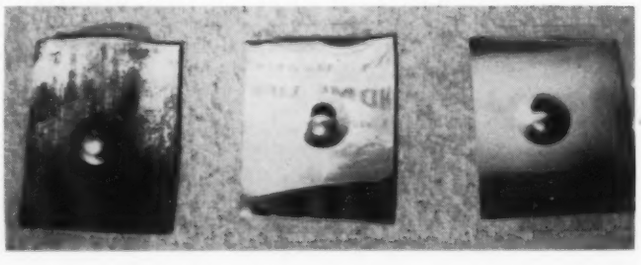
QUALITY OF ANNEALING

The extraordinarily rapid heat transfer obtainable with sodium has the advantage from the product standpoint that the strip can be raised uniformly to the annealing temperature in very short periods, from two to less than one second, so that the much sought after "flash-over" to the annealed condition occurs almost instantaneously.

Annealing tests were made at Chem-Metals Laboratory, in a U-shaped sodium annealer about 30 in. high, of two different kinds and thicknesses of cold-reduced low-carbon steel strip. Figure 4 shows the cold-forming properties, as indicated by the Erichson cup test, of the two different kinds of steel.

It should be noted that in Figure 4, the "time" is the total time of immersion in sodium at the tempera-

Figure 5 — Shown are some cup-test specimens of sodium-annealed strip.



tures marked. With this thin strip plunged instantly into the hot sodium, practically the full annealing temperature was actually reached in a much shorter time, probably less than one second.

Figure 5 shows some of the cup-test specimens of sodium-annealed strip.

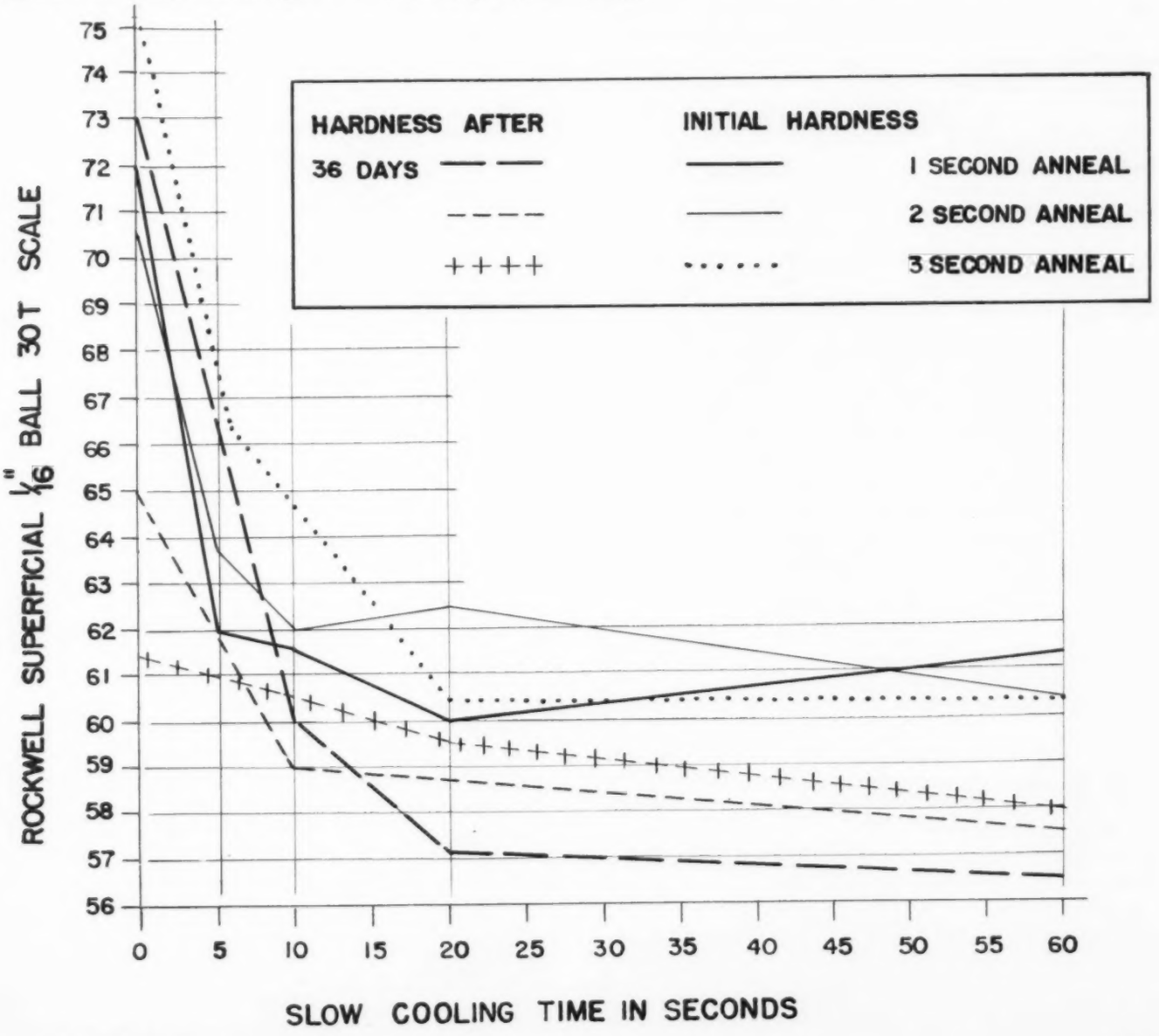
It is not claimed that the strip is annealed to the dead-soft state; that is too much to expect of any method of continuous annealing, although under best conditions, steel "B" did seem to approach the dead-soft state. However, the quality of annealing even for the rather hard-to-anneal steel "A" was always at least equal to and usually better than that obtained in the conventional annealers.

In any discussion of continuous annealing of low-carbon strip the question of "age hardening" always arises; and it is usually stated categorically that a comparatively long slow-cooling period—at least 30 seconds and preferably longer—in the upper part of the temperature range, must be provided if age-hardening is to be avoided. This idea resulted from unwarranted jumping to conclusions on the basis of data from two sets of experiments made about five years ago. It is notable that all tests showing age hardening have been made with comparatively long heating times, five seconds or more to reach annealing temperature. More recently, tests [4] made with heating time as short as 3½ seconds, showed that under these conditions little if any age hardening occurred.

To study the effects of still more rapid heating, tests were made at Chem-Metals Laboratory in Wilkinsburg, Pa., using strip 0.010 to 0.011 in. thick, of steel "A," with 1, 2 and 3 seconds time of immersion in sodium at 1330 F, and subsequent slow-cooling periods of zero to 60 seconds. Rockwell hardness tests of the specimens were made immediately after annealing and again after 36 days. Numerous specimens were tested for each condition, and the results were duplicated time after time.

It can be seen from the results of these tests as plotted in Figure 6 that all of the specimens were actually softer after 36 days than immediately after they were annealed; and that a slow-cooling period of ten seconds is all that was needed even for this rather hard-

Figure 6 — Laboratory tests of 1, 2 and 3-sec, 1330-F annealing of 0.010 to 0.011-in. thick steel show the specimens to be softer, in all cases, after 36 days than immediately after annealing.



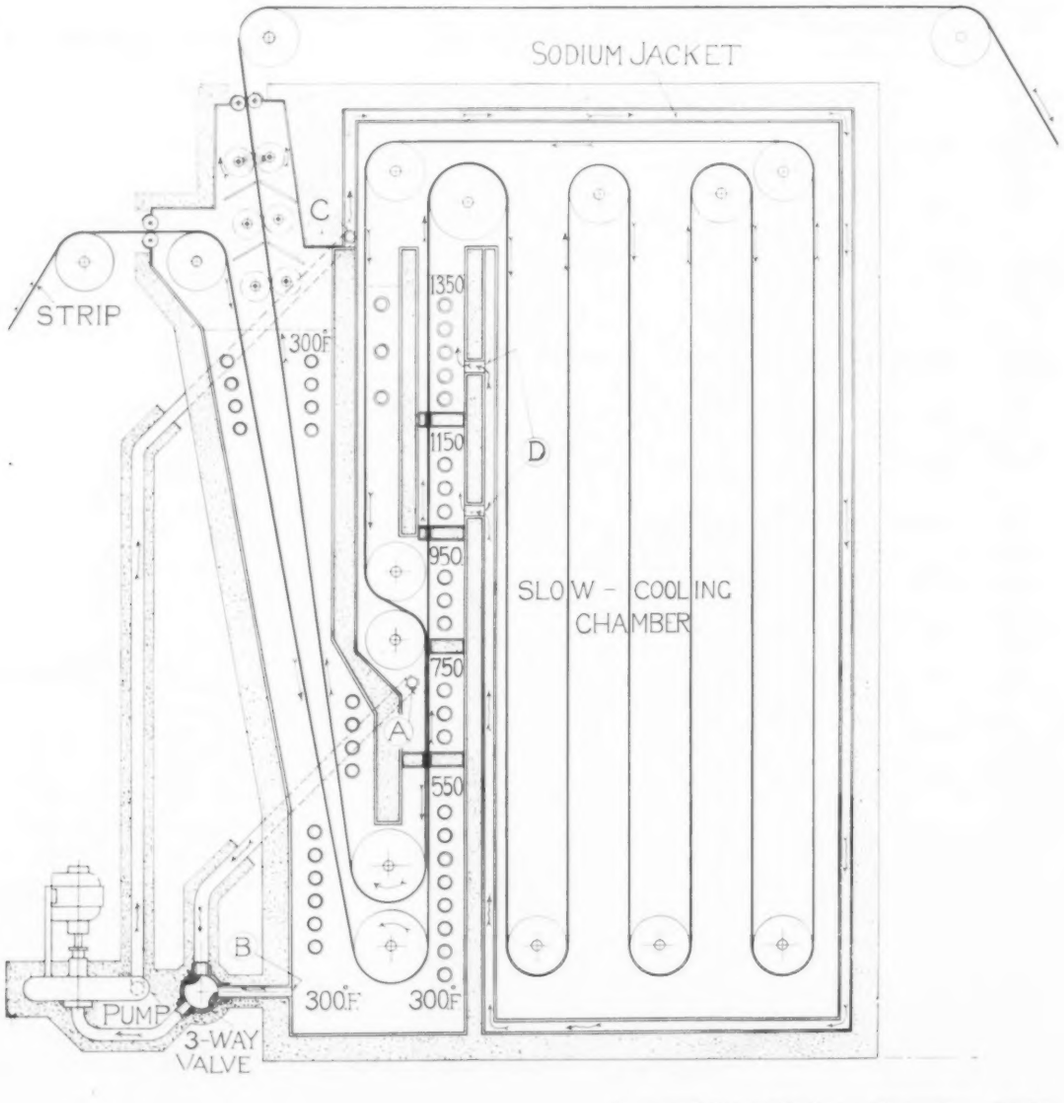
to-anneal steel. Later results with special, but still short-time, cycles have shown still further improvement, dropping the Rockwell hardness by about four points.

No tests have yet been run on steel from oxygen-blown converters, but since age-hardening is now generally thought to be caused by nitrogen (which is extremely low in that kind of steel), it seems probable that no slow-cooling period at all would be required and that sodium annealing should be especially adaptable for and advantageous with oxygen-blown converter steel.

Even with other kinds of steel, improvements in steel-making practice are likely in the near future to make slow cooling unnecessary, by suppressing the age hardening or quench-aging effect. Minute qualities of certain inexpensive additional agents, for example boron, [5] have been shown to combine with the dissolved nitrogen to form stable nitrides. It is the dissolved nitrogen which seems to be chiefly responsible for age hardening, whereas the fixed nitrides seem to have no such effect. The problem now is to develop a technique for making the boron additions, such as will not require laboratory technicians but can be handled by the ordinary steel plant personnel with consistently reliable results. When that is solved, the need for slow cooling after annealing should disappear.

Meanwhile, in cases where a slow-cooling period is necessary, the apparatus would be modified to include a slow-cooling chamber. This chamber could either be sodium-filled, with slow circulation of the sodium in the direction opposite to the movement of the strip, or the slow cooling could be effected in a gas atmosphere and the chamber could be surrounded with a sodium-filled jacket as shown in Figure 7. In the latter case, the sodium could be drawn by a pump from the right leg of the U at a place such as (A) where the temperature is about 800 F, or at (B) where it is 300 F, or by means of a 3-way valve as shown, the proportions from each offtake could be varied. The pump would transfer the liquid to the sodium jacket at (C), whence it would flow within the jacket in a direction opposite to the general direction of the strip motion until it reached outlets (D) through which it would return to the right leg of the U. The heat radiated to the jacket by the strip would have raised the sodium from between 300 and 800 F at (C) to about 1200 to 1250 F at (D). In this way, almost as much heat can be recovered as without slow-cooling. However, this complication would not be necessary if one is willing to accept a fuel consumption rate considerably higher than without slow cooling (but still much less than that of the conventional annealers).

Figure 7 — In cases where a slow-cooling period is necessary, a sodium-jacketed, gas-atmosphere chamber could be added.



CONDITION OF STRIP SURFACE

Short-time immersion in hot sodium makes little difference in the appearance of the surface of cold-

reduced strip. This will be evident from the middle one of the three samples in Figure 5. If a sample is dipped only part way into the sodium, after cooling and washing, the dividing line between the lower, immersed part and the upper part which was not immersed is usually just barely recognizable. The immersed part looks just a little brighter than the original surface.

The surface has however been thoroughly cleaned by the action of the sodium. Any rolling oil present, and also the invisible oxide film on the cold reduced strip, have been removed. That the surface has been rendered chemically clean is shown by the fact that if the strip after removal from the sodium is protected from oxidation and immediately dipped into molten zinc, without the presence of any flux whatsoever the zinc coats the steel at once, forming a tightly adherent zinc layer. The sodium annealing process thus lends itself ideally to a combination with hot-dip galvanizing.

In straight annealing, the surface remains clean and bright after it leaves the sodium annealer, since no visible iron oxide film forms at 300 F. Furthermore, the presence of the very slight amount of powdered sodium, which has much greater attraction for oxygen than steel, protects the surface until it is cooled still further by the water dip. With so clean a surface, atmospheric corrosion might be expected to occur more rapidly, but such tests as have been made have shown less tendency for corrosion of the sodium-annealed than of the untreated strip.

SAFETY OF THE PROCESS

Like the old lady in Wilkie Collins' story "The Moonstone," to whom any mention of chemistry meant that an explosion was about to occur, most people carry over from high school days, even if they remember nothing else, the recollection of the chemistry instructor throwing a bit of sodium into water, resulting in a flash and a bang. The association of sodium and explosion therefore becomes automatic.

Actually, sodium is not in itself explosive. What happens when sodium touches water is that it extracts and itself unites with the oxygen of the water, leaving the hydrogen free to recombine with the oxygen of the air while evolving enough heat to ignite the gas. It is the hydrogen that explodes, not the sodium. Hence if water is kept away from the sodium, no explosion can occur. In the annealer, the sodium is contained in a stainless steel tank with suitable seals, so that no water can possibly reach it. The entering strip must, of course, be dry; but this is asking no more than is already provided by present practice where special precautions are taken to avoid even a trace of moisture which might cause corrosion.

Solid sodium at room temperature or even when warm can be handled, or cut with a knife, without igniting. When ignited either as a solid or a liquid, it burns in air with the formation of a dense white smoke of sodium oxide which is very irritating to the eyes, nose and throat; hence standard ventilating precautions must be taken in the space around the annealer.

What would happen if the sodium container should spring a leak? First, it should be said that in several years' testing in the laboratory with the U-shaped welded stainless steel container, no leak ever occurred. The container was set in a flat pan containing about an inch or two of sand, to absorb the sodium if it leaked out, but it never did. A can of a special powder compound was kept immediately at hand, with which a sodium flame can be smothered.

According to the Liquid-Metals Handbook, [2] if a leak occurs in a sodium tank it usually starts slowly, and at a weld. One company has developed a technique whereby chiller plates are applied to the sides of the tank alongside the leak, to freeze the sodium inside, and the seam is rewelded without even draining the sodium from the tank. In either a pilot or a full-scale sodium annealer, as an added precaution a nitrogen-filled dump tank will be provided below the annealer, into which the sodium can be quickly drained through a pipe connection if any serious leak should threaten to develop.

Altogether, the technique for safely handling sodium has been developed by the Atomic Energy Commission, by the firms making sodium and sodium-potassium alloys, and by users in various industries, to the stage where it is in daily use not only in some of the atomic reactors but in regular production runs in several manufacturing industries.

Several of the materials and processes used in the steel plants are much more dangerous than sodium annealing, yet everyone has become accustomed to living with them and no one thinks anything of it. Hydrogen is used in the annealing of coils of silicon steel and stainless, and is of course highly explosive; so is the gas formed by cracking ammonia, which is three-fourths hydrogen. The de-ox gas used in conventional continuous annealers, while by no means so explosive as hydrogen, on account of the enormous volume in the chambers does present the possibility of very destructive explosions especially during periods of "atmosphere collapse." Molten steel as well as slag are extremely explosive if allowed to touch water. Oxygen under pressure can cause destructive fires. Fuel storage tanks and fuel gas under pressure present their hazards. Yet all of these are in use, in fact modern steelmaking could hardly be practiced without them.

The advantages of sodium annealing are so great that it can safely be predicted that the process will be tried, and once tried and used, it too will be taken for granted or as a matter of course; though certainly the very moderate safety precautions outlined above will always have to be taken.

PRESENT STATUS OF DEVELOPMENT

Seven years of study, engineering development and laboratory work have advanced the design to the point where it is felt that all the important problems have been solved except those, chiefly mechanical ones, which can only be finally solved or rather the proof of their solution furnished by the construction and operation of a pilot line on a fairly large scale.

Fully worked-out designs, though not the detail drawings, for a pilot line to handle strip 0.01 in. thick x 12 in. wide at 1000 fpm, have been available since 1954. The construction of such a pilot line should be the next step in the development, although the engineers of one steel firm stated that they would not have hesitated to skip the pilot-line stage and go at once to a full-scale production unit using sodium, and felt sure they could have made it work. They were not daunted

by the supposed dangers of sodium. Unfortunately they had just completed installation of a conventional annealing line before they learned of the sodium process.

It is a fact that all that now prevents adoption of the new process is the psychological block due to the supposed dangers of sodium, and fear of the new and untried. But the history of the steel industry shows exactly the same pattern in the introduction of other improvements. Some courageous firm has to "break the ice," and once they are successful, then all the others rush to follow their example. It was so in the case of the bessemer converter, of the open hearth process, of pressure blowing of blast furnaces, of the oxygen-blown converter, of the continuous strip mill, and others too numerous to mention. The turning point in the adoption of basic roofs for open hearth furnaces has come only within a year. Adoption of the sodium annealing process in its turn may reasonably be expected.

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Discussion

PRESENTED BY

C. A. TURNER, Chief Metallurgist, Selas Corp. of America, Dresher, Pa.

J. D. KELLER, Partner, Associated Engineers, Pittsburgh, Pa.

FRANK LANNING, Manager, Steel Mill Equipment, Drever Co., Bethayres, Pa.

C. A. Turner: The present large-scale continuous annealing furnaces referred to in this paper are, of course, production proved and represent a big advance over the batch annealing equipment they have superseded. Their development has resulted in substantial reductions in total equipment, floor space requirement, coil handling, coil inventory and in marked improvement in the properties of the annealed product. When this sodium annealer becomes a production reality, it may well be a further advance in these and other benefits.

Our company has long been associated with fast heating and its application to continuous strip processing. These experiences in the laboratory and in the steel mills have involved heating and cooling times paralleling those dealt with in this paper and prompt the comments which follow.

The author cites a sodium annealer to operate at a strip speed of 1000 fpm, or 30 tons per hour, with approximate dimensions of 15 ft high by 6 ft long by 4 ft wide which, with 30 ft of strip travel, implies the simplicity of equipment depicted in Figure 3. On this basis, heating and cooling each take place in slightly less than one second. However, according to the hardness vs cooling time curves of Figure 6, this short cycle results in an annealed hardness of R30t 70 which, in 36 days, age hardens to 72. At this level, the material is unsuited for tinplate under the Tu specification. To meet the Tu requirement (hardness in range R30t 58/62), a 10-second cooling is referred to which then requires the more complex equipment shown in Figure 7 with 10 passes, or some 160 ft of strip travel, in the slow cool chamber. We would therefore ask under what conditions would it be possible to anneal at 1000 fpm with 30 ft of strip travel in the sodium bath and still match results of the present continuous annealers.

The curves of Figure 6 show that for the longer exposure times to molten sodium (two and three seconds) the strip is softer (up to 4 points) after 36 days than immediately following completion of cooling, regardless of the rate. This result is contrary to our experiences and to published data dealing with similar cycles. Can the author offer an explanation of the metallurgical changes in structure which might account for the softening effect? A 36-day delay between the annealing and temper rolling operations is also open to question.

We would also like to ask how a 3-sec exposure to 1350 F sodium would be accomplished? Would the height of the equipment be increased or would multiple passes be made through the bath? In any event, the requirement of extended heating and slow cooling introduces some of the disadvantages attributed to the present continuous annealers. If this is so, then the major benefit of the sodium annealer would appear to be its fuel economy. The importance of this item can be assessed in its relation to the total operating cost.

J. D. Keller: I might say that this matter of the slow cooling time apparently depends a lot on the kind of steel. We have tried not only the two kinds of steel which have been shown in the chart, but a number of others, some of which are extremely hard to anneal and require quite a considerable cooling time, while others require only a short, slow-cooling period, if any. This was just for the straight cycle in-and-out cooling. There are other cycles which have been partly developed (unfortunately I am not permitted at present to say what they are), which can lower this hardness.

I stated in the text that Figure 6 was not to be considered the actual numerical values of the Rockwell Hardness test because they are not fully representative, and by these other cycles which I mentioned which do not require appreciably greater time it is possible to drop the hardness to probably four points lower and at the same time to avoid a long slow-cooling time.

As to the explanation of the softening, I do not know. If you heat up slowly, the carbon or a considerable part of it goes into solution. When you then cool slowly, part of it comes out of the solution, but if you cool fast, it does not have time to do that and some of it is still in solution. As time goes on, even at room temperature the carbon will continue to come out of solution slowly and you have age hardening. The metallurgist suggested that with very fast heating, say in one second or less, the carbon does not have time to go into solution to such an extent and, therefore, you do not have the necessity for or the possibility of its coming out of solution after a period of time. This view, however, is inconsistent with the view that nitrogen is the cause of age-hardening.

The theory might explain why the faster the heating, the less slow cooling is required, but I have no explanation of the softening effect. I do know that we repeated the test time after time on that steel marked "A" in Figure 4 and we found it to exist, beyond question. Unfortunately, we have run out of the steel "B" which is what we started with and we had no opportunity for checking on that. It might have behaved differently.

The last paragraph of Mr. Turner's discussion seems to indicate the survival of the false impression, which I tried to correct in the paper itself, that if any slow-cooling at all is required, the sodium annealer would have no advantage over the conventional continuous annealer except in fuel saving. That idea is entirely incorrect, and I want to emphasize the fact as strongly as possible. The holding-plus-slow-cooling zones, even in the present annealers, require less than 25 per cent of the total number of passes, as shown in Figure 2. Even this should be reduced by at least a half, because less slow-cooling time is required after fast heating in sodium, as explained in the paper. The large "fast-cooling" section in Figure 2 is eliminated by being combined with the heating zone, which itself is negligibly small compared to that of conventional annealers. Add to this the elimination of loopers at both ends, plus the feasibility of stopping the line at will without harming the strip, and the advantage of the sodium annealer even with slow cooling becomes apparent.

Frank Lanning: There are three problems that I would like to mention. You mentioned that in the removing of the residue sodium on the strip you passed it through a quench or water bath. We have had problems which affect corrosion resistance which occur from soluble salts that are found in water from different localities in which the steel mills are located. I am wondering if the problem of keeping the concentration of sodium low enough in the removing bath would present a problem.

The second is a mechanical one. Heat buckles is a misnomer from the standpoint that heat is only one of three causes. Heat buckles are a combination of overstretching or overtension under heat. They are a big function of the rolling or strip shape of the strip coming up to the annealing line from the cold mill and also a problem of heating and cooling. For those who have had the opportunity of looking up into a continuous strip furnace, one of the obvious things that is noticed is the manner in which the strip as it hits the heat definitely twists and turns like a snake through the whole unsupported pass of strip until it gets up near its annealing temperature.

Having had some salt bath experience, I know that one of the main properties of salt bath heating that has been the prime reason for it, is the uniformity which you can obtain throughout the bath with little or no respect to the placement of the heating means because of the high conductivity of the sodium. With that property in mind plus the obvious reason which I just touched on, and because it is necessary to maintain up to a minimum of 4 in. free on either side of the strip pass line in order to insure against strip scratching; I am wondering if it is possible to produce and control the heat gradients mentioned by Professor Keller.

The problem, I think psychologically of handling sodium is one which today is pretty well overcome as far as an objection to the use of it. There are many sodium hydride descaling baths in operation and, as the author properly pointed out, with normal care and respect for the material you are handling, the dangers of sodium are no more than exist in many other processes. The one thing that I would worry some about is the standpoint of the water-cooled seal at the bottom and the possibility of leak occurring there because we have used water-cooled mountings for bearings or water-cooled seal arrangements and defects are bound to show up over a period of time that could cause danger.

J. D. Keller: As to the dip after the bath, I realize that the concentration of sodium would have to be kept low but with the small amount of sodium coming out, that would be no very great problem. However, if there is real objection to a dip, it is possible to brush or wipe off the remaining sodium. One of the difficulties with the sodium as such, in the furnace, is that it is wetting the strip and is adherent. After it is out in the atmosphere it is just a very thin film, a sort of powder, and it forms oxide which when cooled is different from its sticky condition when hot. It does not cling so tightly and there would be no great difficulty in wiping it off.

For one thing, you could again use brushes of organic material. On the hot sodium coming out at around probably 400 F, we tried nylon bristles on the brushes. They just did not stand it at all, at that temperature, but after the strip is out and cooled there seems to be no reason why it could not be wiped with organic brushes or even with pads.

About the buckling question, Mr. Lanning pointed out the factors which cause the buckling and it is realized that we may have to provide a larger clearance than is shown in the sketches. They were more or less diagrammatic. We may have to provide a greater clearance between the incoming and outgoing strands of strip. However, I think that it will be found that in the sodium, conditions are entirely different even from a salt bath as to the rapidity of heat transfer and uniformity of temperature. While the various factors which Mr. Lanning pointed out have a bearing on it, I still feel that nonuniformity of temperature during the heating or the cooling is the chief cause of the buckles and though we do not have in the laboratory any test results on that, I would expect to find that the buckling will be much less than you would have in a conventional annealer or in a salt bath. But even suppose we do have to keep the strands 4 in. apart. The heat transfer of the sodium is so rapid there would be no trouble whatever in getting the heat in or out and transferred from the one strand to the other.

It is realized that water cooling around sodium is a possible source of trouble. However, we should remember that one of the atomic submarines was built and operated with sodium cooling. While I would not myself want to design such a thing where you have water all around, sodium was in fact used and apparently there was no trouble. Also, as mentioned, the water-cooled seal described was actually used and so far as known is still being used in pumps for liquid sodium, without trouble. For one thing the water seal is on the outside away from the high temperature sodium and if water did leak out of the cooling sleeve, it would probably go to the outside. It is realized that care would have to be used in avoiding possible leaks, but the problem can undoubtedly be solved. ▲

Cold Forming

IT is the purpose of this paper to describe the design and use of equipment used for the cold roll forming of sheet, strip and plate metals into useful products as practiced in the United States, with particular emphasis on the design and use of the forming rolls.

Cold roll forming is a process of forming metal from sheet, strip or coiled stock, into shapes of essentially uniform cross section, by feeding the stock longitudinally through successive pairs of rolls, each pair of rolls progressively forming the stock until the finished cross section is produced.

Although cold roll forming can be traced back approximately one-half century, it was the demand for better and faster methods of producing sheet metal parts for the growing automotive industry which was responsible for its rapidly expanding use. Now today, in addition to the extensive use of cold roll forming in the automotive fields, it is widely used to fabricate parts of railway passenger and freight cars and locomotives, building construction components such as: individual structural members; roof, floor and wall panels; partitions; windows, doors and their frames; gutter and down spouts, etc., as well as household appliances, pipe and tubing, toys and many other products too numerous to mention. Figure 1 illustrates different types of shapes which can be produced on cold roll forming equipment.

Products manufactured by cold roll forming vary in size from the toy railway track made from 0.005 to 0.010-in. thick tinplate to steel pipe of ½-in. wall thickness and 26-in. diameter. Carbon steel plate as thick as ¾ in. can be successfully roll formed, and stainless steels have been roll formed in thicknesses from 0.006 to 0.30 in.

ADVANTAGES OF COLD ROLL FORMING

The principal advantage of cold roll forming as compared with other methods of fabrication is high production capacity. Although speeds as high as 300 fpm are reported for the forming of some products, the usual speed does not exceed 100 fpm. A production rate of 3000 to 5000 ft per working hr is not uncommon.

Parts produced by roll forming are essentially uniform in cross section and can be held within very close dimensional tolerances. Although tolerances of the finished part are dependent on the dimensional tolerances of the material being formed, in normal production a part can be held to within ±0.005 in. and, in some cases, a tolerance of ±0.001 in. is practical on small shapes formed from light gage material.

Probably of equal importance with speed and accuracy is the ability to maintain fine surface finishes during roll forming operations. Roll forming can be done on most flat rolled material without injury to the finish. Painted and electroplated materials can be formed without damage to the coating.

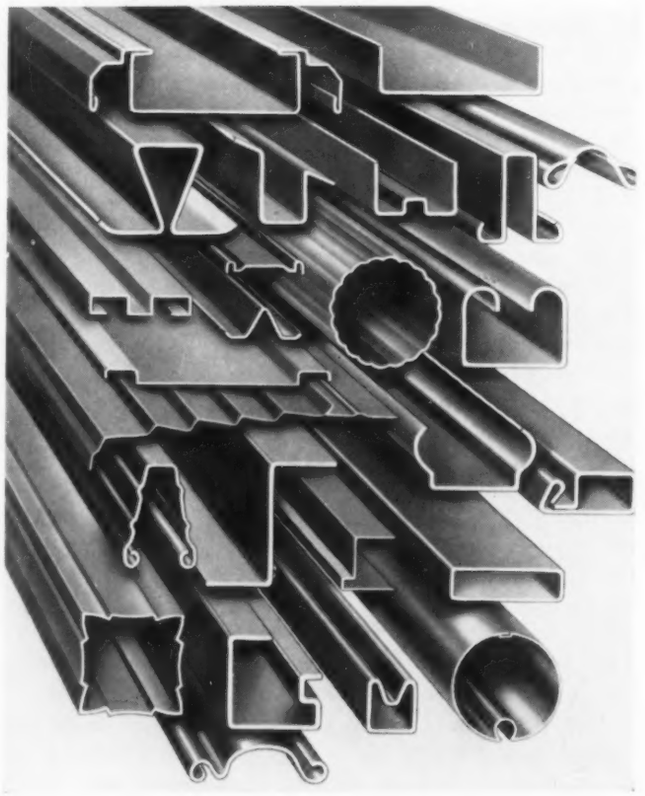
As a result of the ability of cold roll forming equipment to produce finished products with speed and accuracy and to quality surface finishes, real economies can result. It is reported that where continuous production of single sections or collected standard sections involve from, 25,000 to 50,000 lineal ft per 8-hr day, roll forming is by far the most suitable of fabrication processes. It is claimed that where roll forming equipment can be used 25 per cent or more of the time, it is probably the most economical method of manufacture.

COMBINATION OF MATERIALS

Another interesting and important aspect of cold roll forming is that two or more different materials may be fed into the machine at the same time and combined into a single product. Wood, fabric, cord, felt, metal rod, wire or tubing can be incorporated into a roll formed channel or box shape. The manufacture of automobile window guides by forming metal strip around felt weatherstripping is a typical example of the use of this process. Another is the combining of a fabric and galvanized steel strip to form a flexible and sound insulating coupling for air conditioning ducting.

Of particular interest is the fact that two pieces of metal can be combined in such a way that a lighter strip surrounds portions of a heavier strip and thus can provide a section with two or more desirable properties such as high corrosion resistance with high

Figure 1 — These typical sections can be made by cold roll forming equipment.

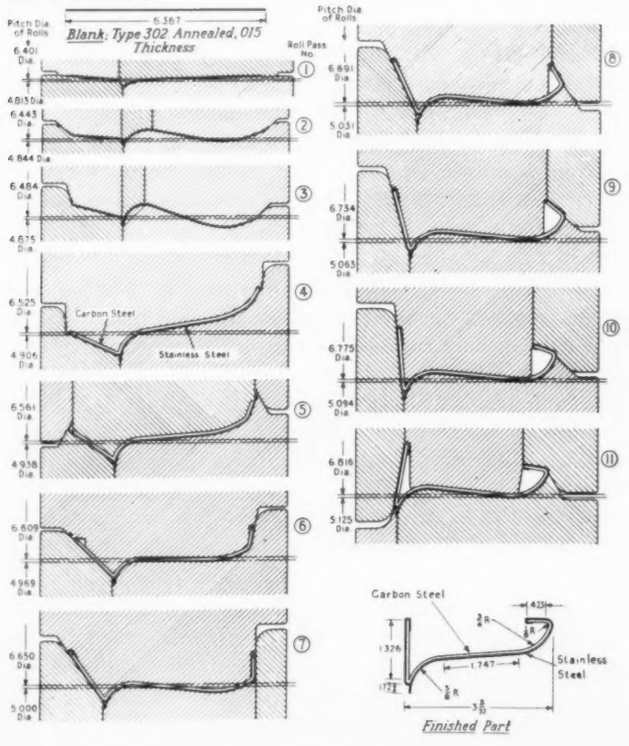


Practice In The United States

ductility or a superior finish on one side with strength, ductility or other properties on the other. Substantial economies can thus result as compared with the forming of a shape from one single strip of high priced metal. Figure 2 illustrates the procedure followed in roll forming a strip of Type 302 annealed stainless steel, 0.015 in. in thickness, around a strip of carbon steel backing. Roll formed sections consisting of a thin surface layer of stainless steel 0.008 to 0.005-in. thick, and a galvanized low carbon steel backing of 0.025 to 0.080 in. thick are frequently used for the trim of automobiles.

It is possible to form multiple sections simultaneously in a single forming operation. Figure 3, for example, shows a section formed from a single strip of carbon steel and two separate strips of stainless steel which are fed simultaneously into a roll forming machine. After forming, the section is slit to make two sections used for automobile radiator grills.

Figure 2 — Roll forming a veneer about a backing is illustrated. Note use of sectioned rolls for ease in machining and adjusting.



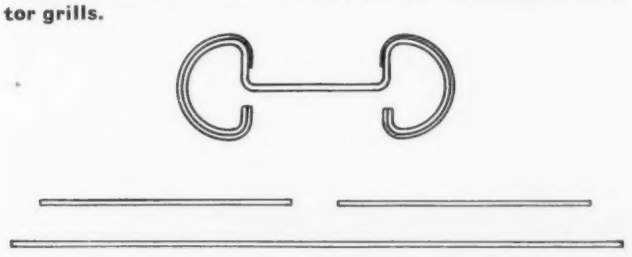
by W. G. Kirkland,
Chief, Engineering Division,
American Iron and Steel Institute,
New York, N. Y.

. . . . presented at a conference of the West of Scotland Iron and Steel Institute in Glasgow, Scotland, on May 16, 1958 . . . . cold roll forming's high production capacity close-tolerance products, and preservation of fine surface finishes is making it an increasingly attractive fabrication process . . . .

ROLL FORMING MACHINES

The typical roll forming machine consists of a welded steel base on which is mounted a series of two, three or more identical roll stands, each designed for holding one pair of rolls. For some light narrow shapes, the so-called outboard type machine is often used. In that machine the roll spindles are supported only at one end, thus better visability and access to the machine in changing and adjusting the tooling is provided. Figure 4 shows a 10-stand outboard type cold roll forming machine.

Figure 3 — This section was formed from two strips of stainless steel and one strip of carbon steel fed simultaneously into a roll forming machine. After forming, the web is slit to make two sections for automobile radiator grills.



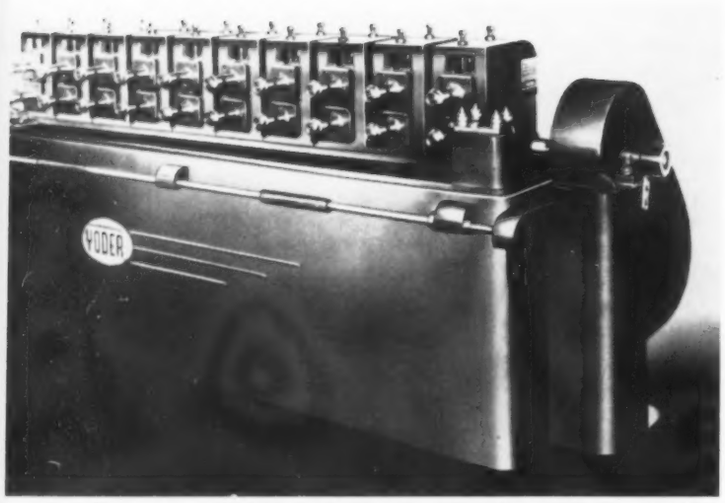
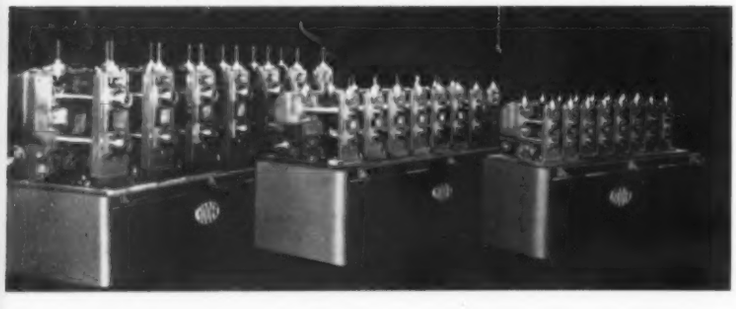


Figure 4 — Outboard type of cold roll forming machine.

The pressures required in forming most structural shapes, however, are such that they impose bending stresses on the spindles which can best be withstood by supporting the spindles at both ends in adjustable, antifriction bearings. When spindles are so mounted, the machine is known as an "inboard" type. The inboard type, being the machine most extensively used, has been standardized by several manufacturers into various sizes forming stock from 0.010 to $\frac{3}{16}$ in. in thickness and for stock widths up to 16 in. However, simply by providing a wider base, these machines can also be used for widths up to 36 in. or more, although the capacity rating in respect to stock thicknesses are thereby reduced due to increased deflection of the spindles. It is also possible to convert some of the inboard machines to outboard types simply by pushing the outboard housings in against the rear housings. Several standard sizes of inboard types of machines produced by one manufacturer are shown in Figure 5. In roll forming, setup time is not a primary consideration, since the life of a set of rolls is quite long and the downtime of the machine is small in comparison to the operating time. Thus, the advantage of decreased setup time in the outboard model is minimized by the nature of the process.

The construction details of a typical inboard forming machine are shown in Figure 6. It consists of an oil tight steel drive housing A, which is interchangeable with any other housing on the machine; tapered roller bearings B, which support the upper and lower spindles D; and steel outboard housing C, which can be moved inward to provide better support when handling

Figure 5 — Three standard sizes of inboard type cold roll forming machine made by one manufacturer.



narrow sections. The vertical distance between spindles can be varied, within limits, by a screw adjustment that moves the entire roll assembly the desired distance in the housings. For accurate adjustment, micrometer dials G are provided on both supports; an additional advantage of the micrometer dials is that the correct settings for any new shape can be recorded to facilitate future setup of the rolls. The upper and lower spindles are driven through appropriate gearing, from the worm gear H. This gear is coupled to the drive shaft on the adjacent housing by a chain type flexible coupling J. The flexible method of drive assembly used permits the easy removal of any housing on the machine[8].*

Figure 7 shows a large machine used for the forming of relatively heavy structural shapes. One such machine for producing shapes was built and installed in 1928 and was continuously used for the purpose until 1942 at which time special rolls for forming steel airfield landing mat sections were installed. In that one year, the machine produced a total of 6349 railroad car loads of the landing mat sections. In 1943 the production of the same shape was 15,652 tons, the machine being intermittently used also for its former work. The production for an 8-hr shift was as high as 100 tons, or at the rate of 50,000 tons per year on a 2-shift basis.

The gearing of the upper and lower spindles in all types of roll forming machines may be equal or unequal depending on whether the rolls are of the same diameter or of different diameters. If rolls are of different diameters, the spindle carrying the smaller roll must operate at a higher rotational speed than the larger spindle in order to equalize the surface speed of the two rolls. Although the unequal gear ratio differs slightly between the various sizes of machines, it is usually about 1.3 to 1. The machine illustrated in Figure 6 is of the unequal gear ratio type.

Thus, the ratio between the spindle gears—whether equal or unequal—forms another basis for classifying roll forming machines. The units with unequal ratios in which the upper or male rolls have a larger pitch diameter than the lower rolls are used to form sections having deep profiles such as the conventional channel form. The reason for this design is purely an economical one. If rolls of equal diameter are used to shape a deep section, the distance between the centerlines of the spindles must be larger. On the other hand, if one roll is smaller than the other, the distance between the spindles can be smaller, and thus the cost of the machine can be less. Many fabricators prefer the machine of greatest versatility and the unequal gear ratio type is, therefore, widely used. The use of the equal gear ratio type is confined largely to plants in which there is a large volume of work on one or more sections of shallow profiles to keep the machine operating at capacity, such as light trim for automotive equipment and furniture.

Figure 8 illustrates the forming of a relatively shallow section and a relatively deep section on rolls having an equal and unequal gear ratio, respectively. The pitch line is selected so as to minimize the effect of differences in the peripheral speeds of the rolls. Scoring, pickup

* Numbers in parentheses refer to Bibliography at end of paper.

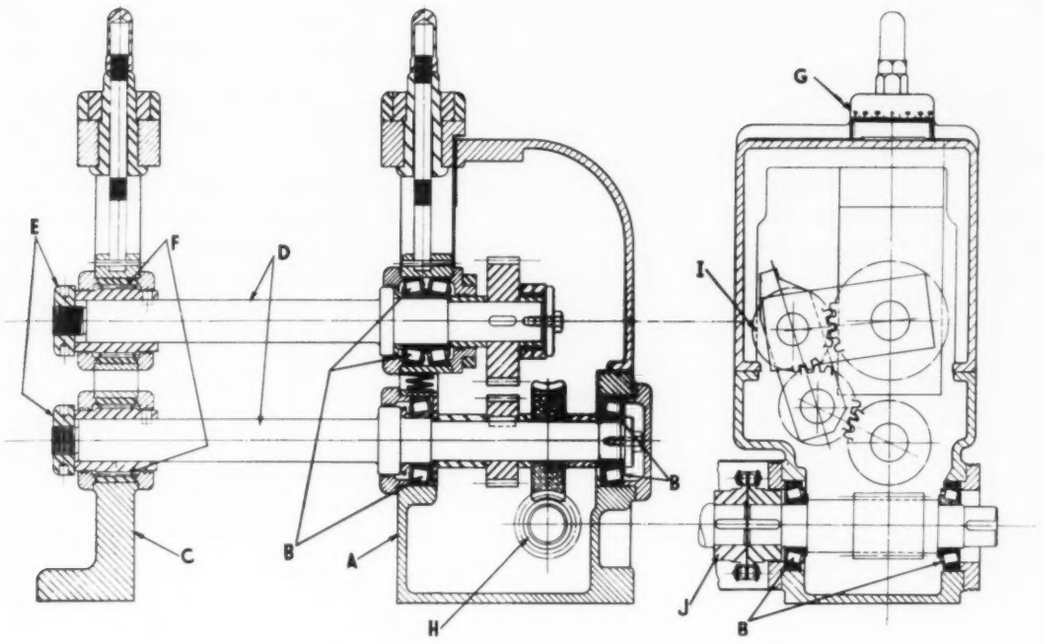


Figure 6 — Cross section of inboard type roll stand.

and excessive roll wear can result from high friction forces caused by differences in peripheral speeds.

The selection of a roll forming machine is dependent upon several factors. The width and thickness of the stock to be used is, of course, one primary consideration. Another important consideration is the shape of the finished product and the amount of forming which is necessary to produce it. Tougher materials, such as the stainless steels, will require more forming work to be performed by the rolls per unit of material than materials such as mild carbon steel and, therefore, may require heavier forming equipment. The amount of work which must be performed by any one pair of rolls to form a specific product is obviously dependent upon the number of pairs of rolls available. The use of a larger number of rolls will reduce the amount of work which must be performed by each and may thereby influence the selection of machine size. The use of an excessive number of rolls, however, is undesirable because of the cost of manufacturing and maintaining rolls.

Cold roll forming machines must have spindles large enough to carry the load through the rolls to form a given amount of metal to the desired shape. To form a deep hat section from heavy gage material will require a machine that can accommodate rolls large enough in diameter to form the depth of the section and spindles sufficiently large to withstand the loads encountered in forming thick materials. Many sizes of machines, having various spindle diameters and horizontal distances between spindle centers are, therefore, required to accommodate the wide variety of work encountered. A simple angle of 16-gage soft steel may be roll formed on a machine having spindles of only 1-in. diameter, while one for forming a ribbed roofing sheet of the same gage, but of high strength steel, would probably require spindles of 4-in. diameter.

ROLL MATERIAL AND PREPARATION

Most commonly used roll material is a medium priced oil hardening tool steel, hardened to 60 to 63 Rockwell "C." When roll forming unpickled hot rolled steel, high carbon, high chromium roll material is used because of its resistance to abrasion. Cast iron and soft machine steel are used for spacer rolls and in some cases, for forming light gage shapes.

Contours and bores of rolls are generally ground after hardening to assure concentricity. The sequence

Figure 7 — This cold roll forming machine is capable of rolling heavy structural shapes up to 18 in. wide and ½ in. thick from high strength steels.

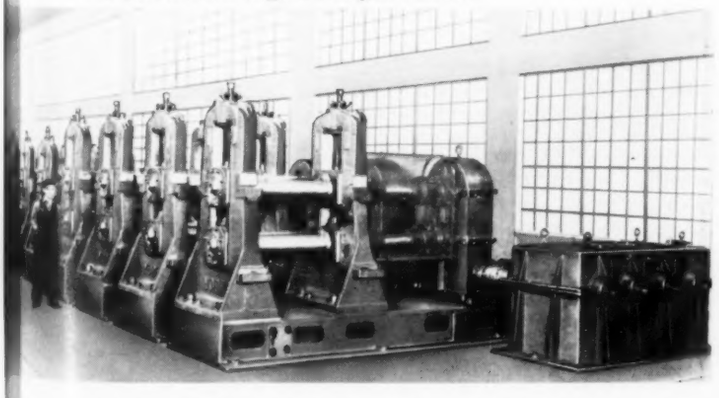
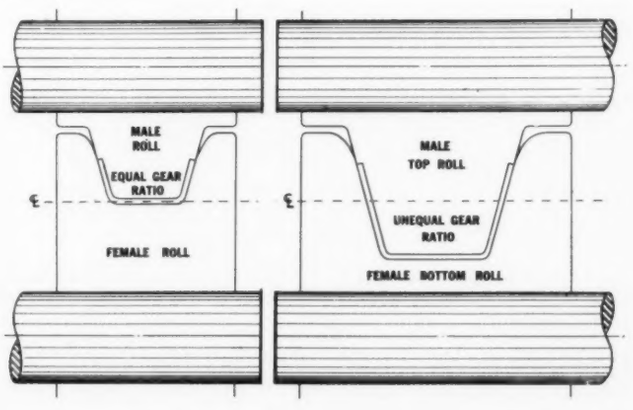


Figure 8 — Offsetting the pitch line for roll forming deep sections.



generally employed in grinding rolls is to bore grind, then surface grind the faces, and finally grind the forming surfaces. Solid rolls are mounted on expanding type arbors, while split rolls are held on a threaded arbor. Split rolls are ground together as if they were solid. Before removing the ground rolls from the arbor, the pairs of rolls are always checked and matched for proper clearances before mounting on the machine.

The ground finish is generally suitable for forming hot or cold rolled steel sheets, but highly polished rolls are necessary for forming stainless steel and enameled or coated stock. Chromium plated rolls are frequently used for forming highly polished or coated material.

Rolls are generally made in sections for convenience in machining, handling when mounting on the machine and replacing of worn sections. Split rolls are used effectively in the forming of Z-shaped structural members and in the forming of the slat section for roller curtain doors.

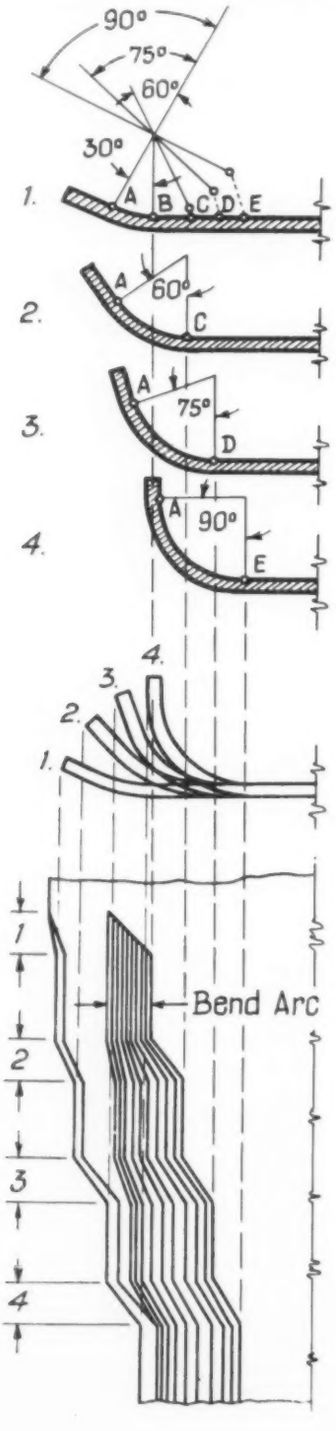


Figure 9 — Progressive development of bend by roll forming.

The life of a set of rolls depends on the type of material being formed, the gage and shape being formed, and the care which is given them. Rarely is a complete set of rolls replaced due to wear. If parts of rolls subject to wear are replaced when worn, and before extra work is placed on succeeding roll passes, the set of rolls will last indefinitely.

The same set of rolls frequently can be used to form a given section from different materials. It may be necessary, however, to change parts of a series of rolls designed for one material in the forming of another material, particularly those critical rolls which control and compensate for the differences in springback which may occur. If a set of rolls is designed for the toughest material which will be formed, then usually the same set of rolls can be used without change for softer materials.

With machines designed to accommodate varying roll diameters, the complete sets of rolls can be redressed a number of times, reducing the diameters each time, but maintaining the contours of the rolls to produce a shape within the required tolerance. Rolls have produced up to 5,000,000 ft without redressing and up to 50,000,000 feet or more when properly redressed and maintained. Modern roll forming machines are all provided with roll lubricating systems which add greatly to the life of the rolls and help to produce a better product.

IMPORTANCE OF PREPLANNING

All of the engineers engaged in roll design agree on the importance of close collaboration between the product designer responsible for the determination of the form of the finished rolled product, including the dimensional tolerances specified and the roll designer himself. Without such collaboration it is possible for a relatively simple forming job to be made difficult and the difficult forming job to be made more so. Not only may the cost of manufacturing the product be substantially increased by the lack of such cooperation, but its quality may also be adversely affected.

GENERAL CONSIDERATIONS IN ROLL DESIGN

The most important and also the most difficult part of the design of forming rolls is the planning of the progressive shapes of the material and thus the determination of the number of roll passes necessary to form a given shape. Not being an exact science, it requires experience, good judgment and a knowledge of the bending of metals. According to some authorities, the satisfactory design of rolls is at least 80 per cent based upon experience and judgment and perhaps 20 per cent upon science.

When considering the design of a section whose probable quantities will warrant cold roll forming the designer may be guided by several general rules:

1. Avoid extreme depth of section. The available roll forming machine may control this factor.

2. Avoid long vertical side walls where possible. A slight angle is an aid to forming and reduces metal scoring and unnecessary roll wear.

3. Avoid blind corners or radii. Forming accurate sectional dimensions is easier where the section can be controlled by the rolls.

4. Give careful consideration to bend radii used. In some cases, a product having relatively small bend radii can be more satisfactorily formed than one having relatively large bend radii. The outside radius must, however, ordinarily be at least equal to the metal thickness. The type of material being formed governs the possible inside bend radii. Ductile or untempered metals can be formed to zero inside radius, but tempered metals require greater radii to prevent cracking. Many handbooks give standard bend radii for materials based on brake forming or other methods of straight bending. As a "rule of thumb," these standard bend radii may be reduced one thickness for roll forming.

Several methods of forming bends are used. The method employed depends on several important factors including the thickness of stock, type of material and size of the radius. One method employed when the desired radius is small compared to the thickness of the stock is illustrated in Figure 9 (not necessarily to scale). This method may not be desirable for bends of large radii, however, because noticeable imperfections may occur at tangent points between curved and straight portions at each successive pass, particularly in forming plated or coated stock.

Another general method used in forming bends is to decrease the radius of the bend while working the same amount of material in each pass.

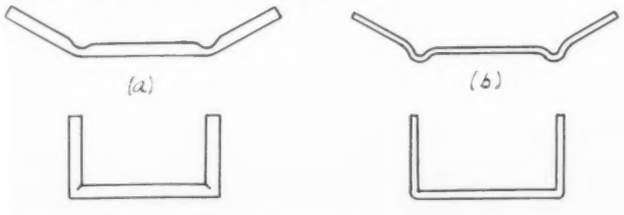
Combinations of the two above described methods for forming bends, as well as variation on each of them, are frequently used. The selection of the method to be used in a specific job must be based upon experience and judgment.

ROUNDED OR BEVELED EDGES AND SHARP CORNERS

In some cases, it is necessary to round or bevel the edges of a section. In others, sharp corners are desirable. Rounding or beveling operations are normally performed with conventional rolls, but forming of sharp corners can only be done after a grooving or beading operation has been performed on the stock or after the section has been specially preformed for this purpose.

If grooving is necessary, the groove should penetrate the material from one-third to one-half of its depth. The strip can then be forced into a sharp corner of the

Figure 10 — Shown are methods for forming sharp corners. Thick stock can be grooved as shown in (a), whereas on thin stock, sharp corners are usually obtained by first forming beads as shown in (b).



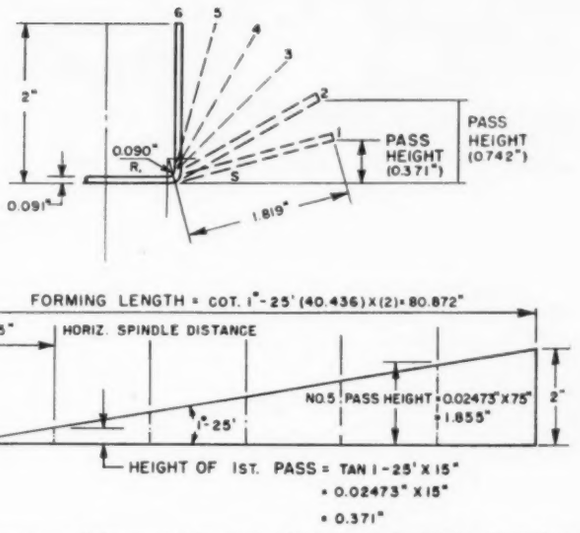


Figure 11 — Schematic layout of the pass heights, forming angle, spindle distances and forming length employed to produce 2-in. high channel.

roll and formed as shown in Figure 10. Where strength is an important factor, this method has the disadvantage of weakening the section at the bend. Its use is generally limited to stock thicknesses of more than 0.032 in.

The preforming method, used for lighter gages, is illustrated in Figure 16(b). The section is first formed with a sharp bend at the corner or corners, after which the bends are transformed to sharp corners in succeeding roll passes.

FORMING ANGLE METHOD OF ROLL DESIGN

It is not possible to reduce all of the factors which influence roll forming to mathematical terms and thus obtain formulas by which rolls to form a specific job may be automatically selected. A rule of thumb which, according to some roll form designers, has been found to be a dependable guide for the determination of the number of roll passes required for simple shapes of carbon steel is the following (7):

$$L = 40.436H$$

Where:

L = the forming length, in.
40.436 = the cotangent of 1 degree, 25 minutes
H = the height of the desired section, in.

Applying this rule to a 2-in. high channel, it is determined that the forming length required would be equal to 40.436 × 2 or 80.872 in. If the horizontal distance between spindles on the machine to be used is 15 in. the number of roll passes which should be used is 80.872 divided by 15, or 5.39. Thus, 6 roll passes (5.39 raised to the next highest whole number) should be used to form the desired channel.

The above calculations are for one bend. It is obvious that the section is symmetrical and that both bends can be accomplished at the same time. For multiple bends on complicated shapes, the section must be broken down and each bend or pair of bends calculated individually to determine the number of passes required to perform that bend. The total number of passes

Figure 12 — "Flower" for determining number of roll passes.

can then be determined by combining passes whenever practical.

The calculation of the form of the successive shapes which would be used in the forming of this section is indicated in Figure 11.

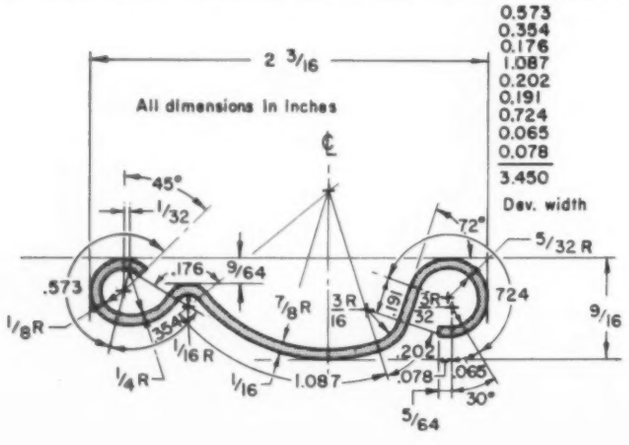
Other roll form engineers believe that the above described roll design procedure may not always give the optimum results. They report that in some cases for relatively ductile steels a forming angle of as much as 3 degrees might be satisfactorily used in lieu of the 1 degree, 25 minute forming angle used in the calculation above. Recommended practice for the forming of stainless steel is that the vertical dimension should not be increased by more than $\frac{1}{4}$ in. in a horizontal distance of nine in. between successive rolls (9). This limitation would correspond to a forming angle of 1 degree, 35 minutes and thus compares favorably with the 1 degree, 25 minute recommended forming angle.

FLOWER METHOD OF ROLL DESIGN

Assuming that one has the special skills necessary, it is possible to design a set of rolls to form a specific shape without consciously resorting to the use of an arbitrary forming angle. The experienced roll forming designer can use the so called "Flower" method in determining the amounts of progressive forming which should be performed and thus the number of roll passes necessary. The method derives its name from the appearance of the superimposed drawings of the shape as it passes each successive set of forming rolls. Figure 12 shows the flower pattern for the development of a slat for roller curtain doors commonly used in warehouses and factories. Planning of successive stages in roll forming is also simplified by starting with the finished shape, perhaps in the form of a bent wire, and unfolding it to the flat section.

Illustrations (15) and roll design calculations for the forming of this slat section follow.

Figure 13 — This is a layout of finished section and dimensioning for determination of width of strip required.



Following receipt of the cross-sectional drawings or a sample of the desired products to be roll formed, the roll form engineer proceeds with the preparation of layout drawings. On each drawing, the shape is divided into its component curve and straight sections and by using simple trigonometry, the developed width along the neutral axis is calculated for each of the component parts. The stock width required for producing the desired finished shape is obtained by totaling these individual developed widths in the lay-out drawing for that shape. The developed width of the slat section under consideration is 3.450 in. as indicated in Figure 13.

A machine with $2\frac{1}{2}$ in. diam spindles is chosen for roll forming this shape because it is to be in production over a long period of time and would possibly encounter extreme variations in gage and hardness of material. The slat has a greater number of bends than the average shape, and the bends must be held to close tolerances because the two edges form a hinge when the pieces are assembled into a door.

To decide in what position a shape should be roll formed, a number of factors must be considered. A shape is usually positioned so that forming is in an upward direction. For example, a channel or angle is roll formed with the legs pointing upward. Deviations from this rule are sometimes necessary to enable other operational or handling problems to be more conveniently solved. Cutting off in a flying shear may require a certain roll forming position. Material with a highly polished surface on one side is better formed with the polished surface on top so that any blemishes or scratches on this surface can be quickly detected. The same is also true for prepainted material. Since there are no problems of this type with this slat shape, it is rolled in the position shown, one in which most of the forming was in an upward direction.

When starting design of the rolls, a vertical center line is first established. This is the line that fixes the path of the metal as it passes through the rolls and is generally through the middle of the roll space on the spindles. In this case, with a 15-in. roll space, the centerline is established $7\frac{1}{2}$ in. from the flange, or stop, on the spindle which is on the right side of the drawings. The vertical centerline of this shape is established on the centerline of the $\frac{7}{8}$-in. radius and shows clearly in Figure 14. For convenience, the drawing line or pitch line of the rolls is established as a horizontal line at the bottom of this radius where it is intersected by the vertical centerline. Along this line are established the pitch diameters of the rolls.

Theoretically, the pitch line established for the first forming pass also determines the pitch diameter of the rolls for all the passes. However, as the strip elongates slightly due to the roll pressure, the pitch diameter of each succeeding pair of rolls is slightly increased in practice, so as to maintain a slight tension on the strip and thus prevent buckling.

To maintain the necessary tension on the strip as it is being formed into the slat section, the pitch diameter is stepped up $\frac{1}{32}$ in. (0.031 in.) in each pass on the bottom rolls. The top rolls are also stepped up to maintain the correct speed ratio between top and bottom rolls. The gear ratio of the machine used in this case is 1.3 to 1. The slat could have been formed on a

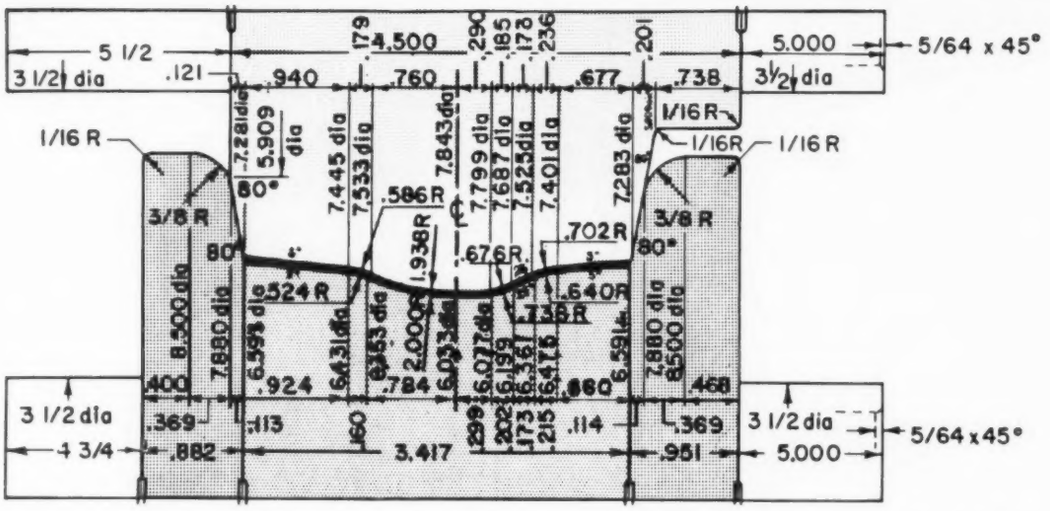


Figure 14 — Dimensioning necessary for machining first roll pass for forming roller curtain door slat.

machine with a gear ratio of 1 to 1 because of its shallow depth, but depth capacity of the machine for other shapes would have been sacrificed.

As the last roll pass diameter is generally used to calculate stock speeds, a roll diameter is established on it enough greater than the minimum for the machine to allow for redressing of the rolls to compensate for wear. In this instance, the minimum bottom roll diameter for the machine is 5 in. and the pitch diameter of this roll is taken as 6.250 in., allowing 1¼ in. for redress on the rolls. The pitch diameter of the top roll for the last pass is, therefore, 1.3 × 6.250 or 8.125 in. Starting with this 6.250-in. bottom roll diameter on the last pass and stepping down 1/32 in. on each preceding bottom roll, the pitch diameters for all of the rolls are determined.

The design and detail drawings of the individual forming stages is now completed. Figure 14 shows the first stage with all dimensions necessary for machining the rolls to desired shape and size.

Rolls are split into pieces primarily to simplify their manufacture. Such design also facilitates mounting rolls on the spindles and permits a limited amount of correction in the rolls if found necessary during test. Both the top and the bottom rolls are narrower than the space on the spindles and are centered on the spindles with spacers.

The spacers on the right, which is the flange end of the spindle, have width dimensions in decimals because the 7½ in. dimension established from the flange on the spindle to the centerline of the shape must be accurately held. The outside spacers shown on the left side need not be made to such an accurate width because they are backed up by a threaded nut. All spacers are made of machine steel or tubing, only the bore and width of which are machined.

Separated flanges are used on each side of the bottom roll to position the metal over the rolls. They are separate from the main body of the roll to facilitate changing the width of the bottom roll if this should have been necessary. As shown in Figure 14, these flanges are tapered 10 degrees from the vertical on the sides that contact the metal and have a large radius to guide the flat strip into this roll pass. The diameter of the flanges is such that the space between them at the outside is more than the width of the material as it enters the rolls. The material will then be guided by the flanges into correct forming position. Rolls for passes

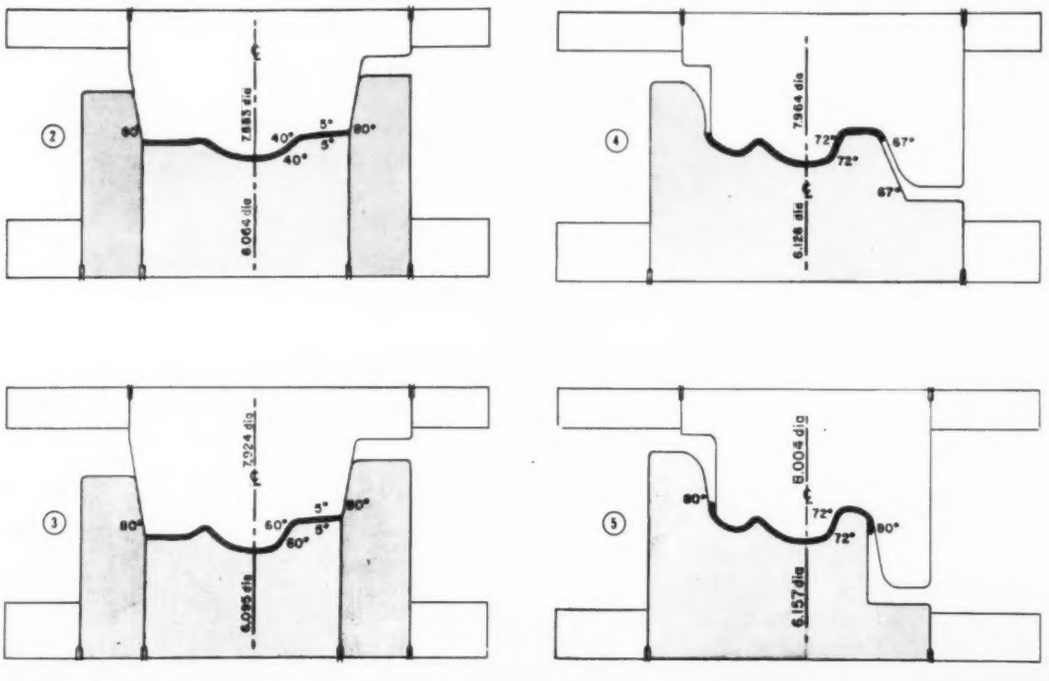


Figure 15 — These are the rolls for passes No. 2 through 5 for forming of roller curtain door slat.

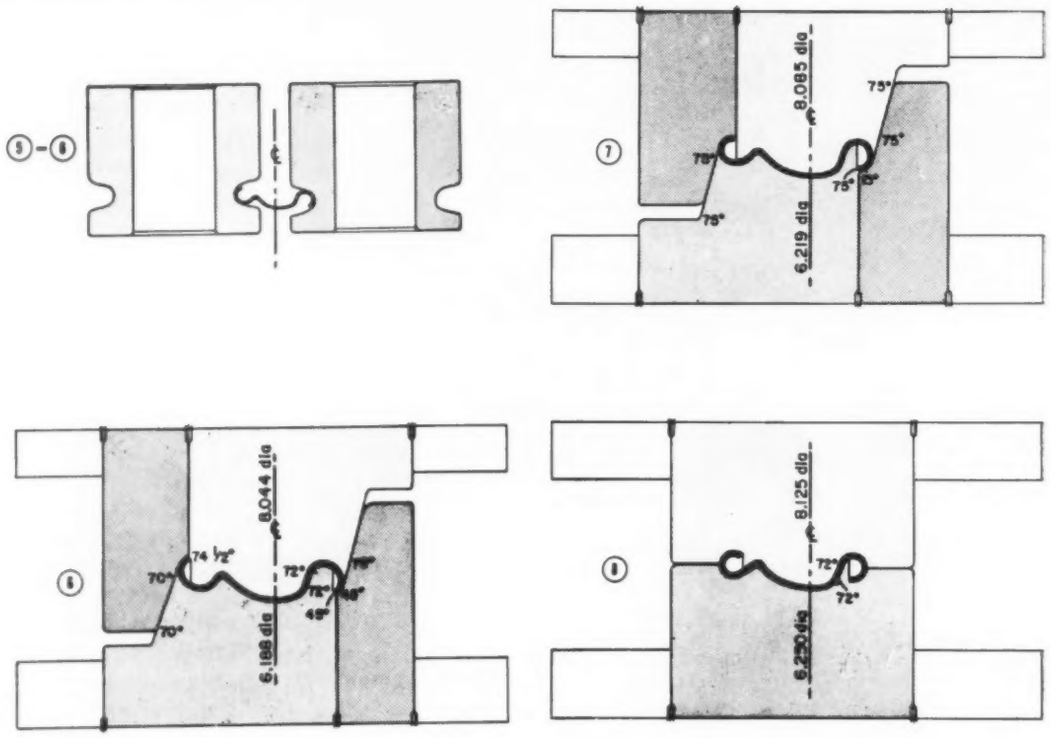


Figure 16 — Shown are the rolls for passes No. 6 through 8 for forming of roller curtain door slat and idler rolls which precede pass No. 6.

No. 2 and 3, Figure 15, have flanges of the same design for the same purpose.

In all the roll passes, the forming flanges are on the bottom roll when the metal is formed upward and on the top roll when the metal is formed downward. Figure 15 illustrates both conditions. All changes in contour of the rolls are dimensioned both for diameter and width, and all angles are given from the horizontal to avoid confusion.

When the middle of the shape has been formed to the final contour and the curling of the sides is started, both top and bottom rolls are made of one piece. It is no longer necessary to confine the edges of the strip. Flanges are at the right of the top roll and at the left of the bottom roll at pass No. 4 because they are needed to force the material down and up, respectively.

In the next stage, pass No. 5, the middle of the slat section remains the same but the edges are starting to be formed. The middle portions of all succeeding horizontal rolls are the same because no further forming is required in this section of the shape.

The next stage, Figure 16, uses a pair of rolls mounted on vertical spindles that are adjustable horizontally. These rolls are not driven, but are mounted on anti-friction bearings so that they rotate from the action of the shape being pulled through. Vertical rolls are necessary because the shape is being formed in a horizontal direction and, without these rolls, the shape would not enter the succeeding roll pass without scuffing on entering.

The first stage beyond the vertical rolls, pass No. 6, causes progression in shaping the sides of the strip. Rolls that complete the shape of the strip are shown in passes No 7 and 8 and are designed to surround the material as much as possible.

FORMING A Z-SECTION

Figure 17 illustrates the progressive forming of a Z-shaped structural section, by the use of five pairs of rolls (13). By forming the section in the position shown, it is seen that vertical surfaces are eliminated and that the section can be surrounded with a maximum of roll surfaces. Positioning of the Z-section in the rolls as shown in Figure 17 minimizes the amount of twist which will exist in the finished section. Note that it was possible in this case to use a zero radius on the female rolls in passes No. 3 and 4, and to split the rolls at this point, resulting in a substantial simplification of the roll manufacture. It is necessary, however, that the section be fully surrounded at the bends in the last roll, and this is shown in pass No. 5. The roll diameters must be mating at all working surfaces in the last pair of rolls.

ROLLS FOR FORMING AND SIZING WELDED TUBE AND PIPE

The mills for producing welded tube and pipe are made in a range of sizes, producing welded tubing from ¼ up to 26 in. in diameter and with wall thicknesses from several thousandths of an inch up to ¾ in. thick. The mill generally consists of a forming machine for forming the strip of material into a tubular form, a welder to weld the seam, a cooling unit, and a sizing and straightening machine for finally sizing and straightening the tube to the required lengths.

Rate of production for welded tube and pipe mills is generally dependent upon the possible welding speed. For larger mill type machines the rate of production is frequently 40 to 60 fpm. One such machine used for forming pipe up to ¾-in. wall thickness and 20 in. diameter is reported to have an annual production capacity of 180,000 tons on a single shift operation (2).

There are a number of methods and designs used for forming strip into a tubular shape suitable for welding. There are many factors to be considered in choosing the proper design of rolls for producing a particular tube. Several of these methods are described and

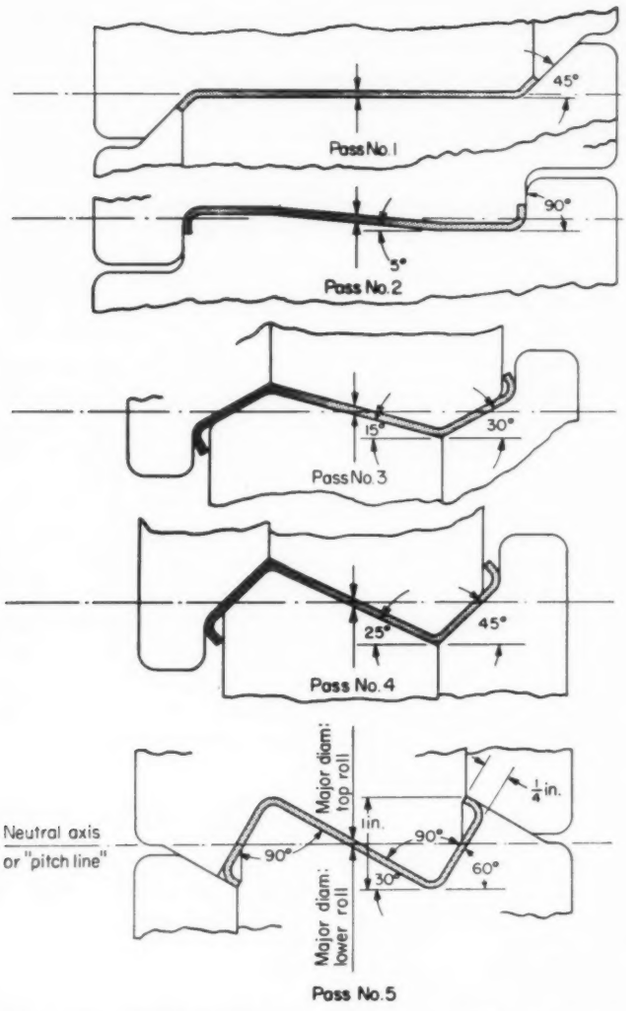


Figure 17 — Rolls for the progressive forming of a Z-shaped structural section.

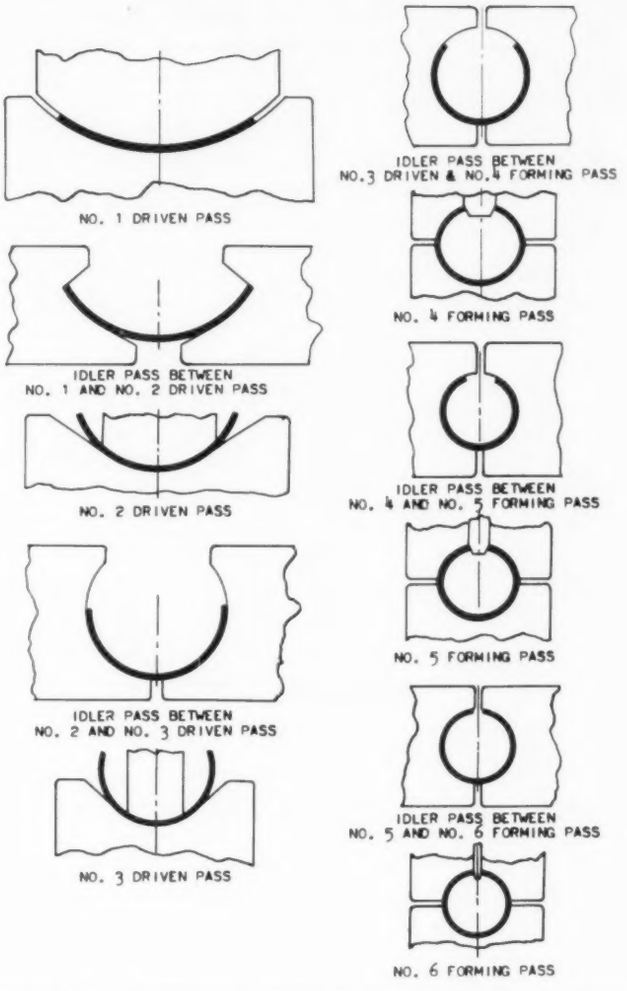

NO. 1 DRIVEN PASS
IDLER PASS BETWEEN NO. 1 AND NO. 2 DRIVEN PASS
NO. 2 DRIVEN PASS
IDLER PASS BETWEEN NO. 2 AND NO. 3 DRIVEN PASS
NO. 3 DRIVEN PASS
IDLER PASS BETWEEN NO. 3 DRIVEN & NO. 4 FORMING PASS
NO. 4 FORMING PASS
IDLER PASS BETWEEN NO. 4 AND NO. 5 FORMING PASS
NO. 5 FORMING PASS
IDLER PASS BETWEEN NO. 5 AND NO. 6 FORMING PASS
NO. 6 FORMING PASS

Figure 18 — Progressive stages in forming of tubing and maintaining a single forming radius in each roll pass.

illustrated here and the factors governing their choice are discussed.

Figure 18 illustrates one of the most commonly used designs of rolls for forming the tube before welding. The rolls are designed with a single forming radius in each roll pass. This radius progressively decreases in each roll pass until the final pass, which is only enough larger than the finished tube size to permit a thin fin to be inserted in the top roll to act as a guide for the two edges of the material. Generally, the last two or three roll passes are provided with fin rolls in the top rolls to guide the two edges of the strip, prevent twisting of the tube, and to assure accurate position of seam entering the welder. Idler rolls mounted on vertical spindles between the driven roll passes are positioned to prevent excessive rubbing and scuffing of the side of the tube as it passes through the succeeding driven roll passes. The number of driven roll passes can vary, increasing as the tube diameter increases, but five driven passes is considered a minimum. With the forming radii on the rolls designed for a given gage of material, this design of rolls produces a satisfactory tube from material as much as 40 per cent less in thickness than that for which the rolls are designed. To accommodate other gages, new top rolls can be provided to maintain the proper fit between top and bottom rolls. The same final fin roll passes are used for all gages of material. This design of roll produces high grade tubing when the ratio between the wall thickness or gage of the material and the outside diameter of the finished tube is between 3 and 10 per cent, and the material being formed is half hard or softer.

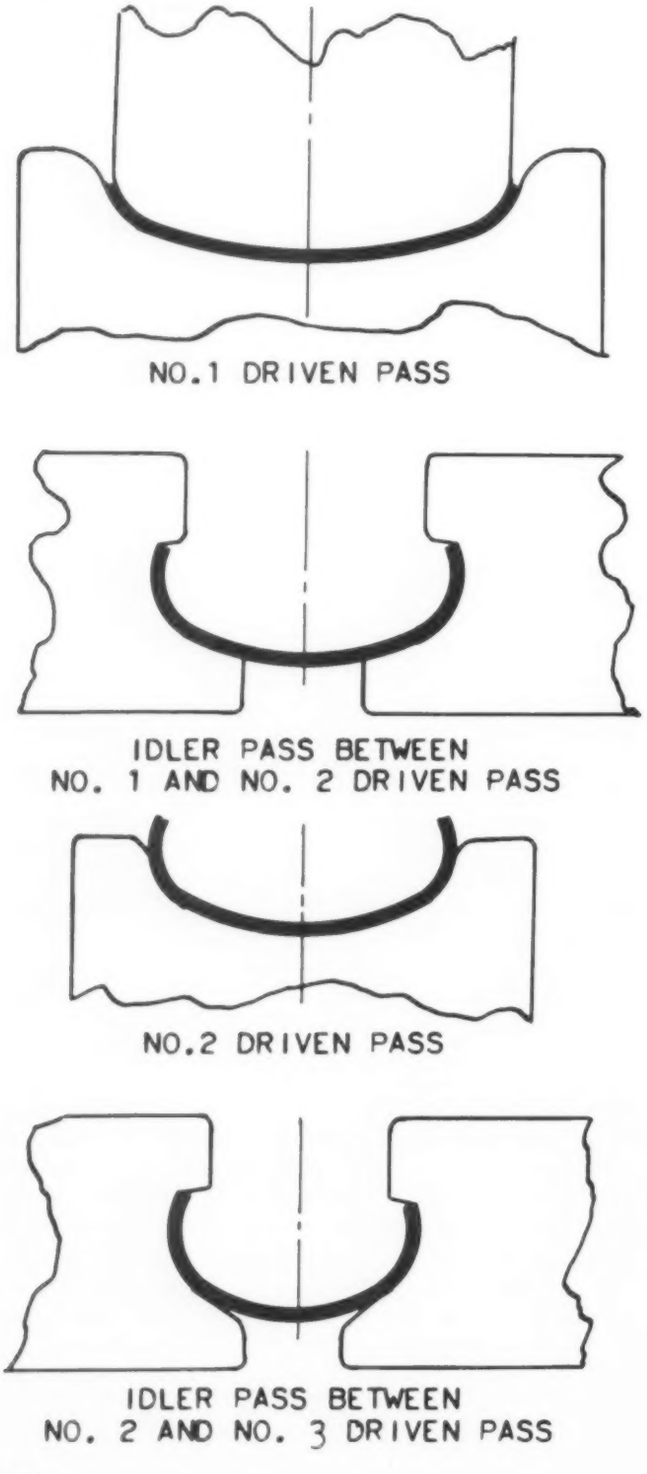
For forming tube with either a very thin wall or a very heavy wall (wall thickness under 3 per cent of OD of tube, or over 10 per cent of OD of tube), a modification of the design shown in Figure 18 is used. This modification consists of forming the strip adjacent to the edges to the finished radius of the tube in the first forming passes, instead of depending on the fin passes to finish form at the edges. This finished form at the edges of the strip helps to prevent buckles and waviness at the edges of the strip as it passes through the forming rolls when very thin material is being formed. It helps to avoid the necessity of extreme pressures at the fin rolls when forming extra heavy gage material. Figure 19 illustrates the first two sets of rolls used in this method of tube forming. The remaining rolls are similar to those shown in Figure 18.

In forming material of high tensile strength when springback of the metal is a factor, a third method of forming is sometimes used. In this design a part of the strip is formed to the finished tube radius in each roll pass, progressing from the two edges toward the middle until the fin passes are reached. The forming radius on

the rolls is enough less than the finished radius of the tube to compensate for the springback of the material. The first three passes for this method of forming are illustrated in Figure 20.

A number of slight variations from the designs shown can be found in practice. The number of driven forming passes can vary. Some of the vertically mounted idler rolls are sometimes omitted. The number of fin passes varies from one to three, and on some designs the tube is closed completely in the final forming pass eliminating a fin entirely. The shape and diameter of the roll flanges vary slightly. Rolls are sometimes split, especially in the larger sizes, for ease in mounting and also to permit regrinding the sides of the flanges when worn, compensating for the amount of regrinding by face grinding the rolls at the split.

Figure 19 — Where waviness of edges in forming of tubing may be a problem, forming passes No. 1 and 2 shown in Figure 18 can be modified as shown in Figure 19.



ROLLS FOR SIZING AND STRAIGHTENING TUBE AFTER WELDING

Tube and pipe is welded to an outside diameter slightly over the finished diameter. The sizing rolls can then produce round, accurately dimensioned, straight-finished tube. A typical set of sizing and straightening rolls consists of three driven roll passes, vertically mounted idler rolls between each driven pass, and finally a set of idle cluster rolls which are adjustable both vertically and horizontally for final straightening of the tube. The roll radius for each driven roll successively decreases the size of the tube down to its proper diameter. As an example, to produce a tube 1.000 in. in diam, the radius in the first drive sizing pass is made 0.502 in., the second driven pass 0.500 in., and the third driven pass 0.497 in. The idler rolls between the driven passes would have a 0.515-in. radius, and the final cluster rolls for straightening the tube would have the nominal radius of 0.500 in.

MOUNTING ROLLS

Before mounting rolls on the forming stand, each pair must be careful'y matched on a surface plate to assure proper clearances for the metal passing between them. This careful checking saves considerable time in testing the rolls on the machine. The finished shape must come from the rolls reasonably straight and free from twist. Any extreme curving or twist indicates incorrect adjustments or matching of rolls, and must be corrected in the rolls for successful production of the shape.

After a set of rolls has been completed, they must be tested on the machine and adjusted to eliminate bowing, twisting or wrinkling. At this time, the micrometer settings should be recorded, so that when the rolls are removed and later remounted for the same shape, they can more easily be set up and adjusted.

The length of time required for each roll setup depends, of course, on the intricacy of the section to be formed as well as on the general aptitude and experience of the operator.

ROLL FORMING ACCESSORIES

With a roll forming machine, certain accessories are required to guide a strip of metal into, through and out of the forming rolls and to assist in the forming operation, mainly by exerting side pressure on the strip. The number and design of these accessories vary somewhat to suit each set of forming rolls, but they are basically similar. Included in the classification of accessories are starting guides, bar type guides, idler rolls and straighteners.

Broadly speaking, guides are designed for three primary purposes: (1) to keep the stock in proper alinement with the first pair of forming rolls as it is fed into the machine: (2) to prevent vertical and

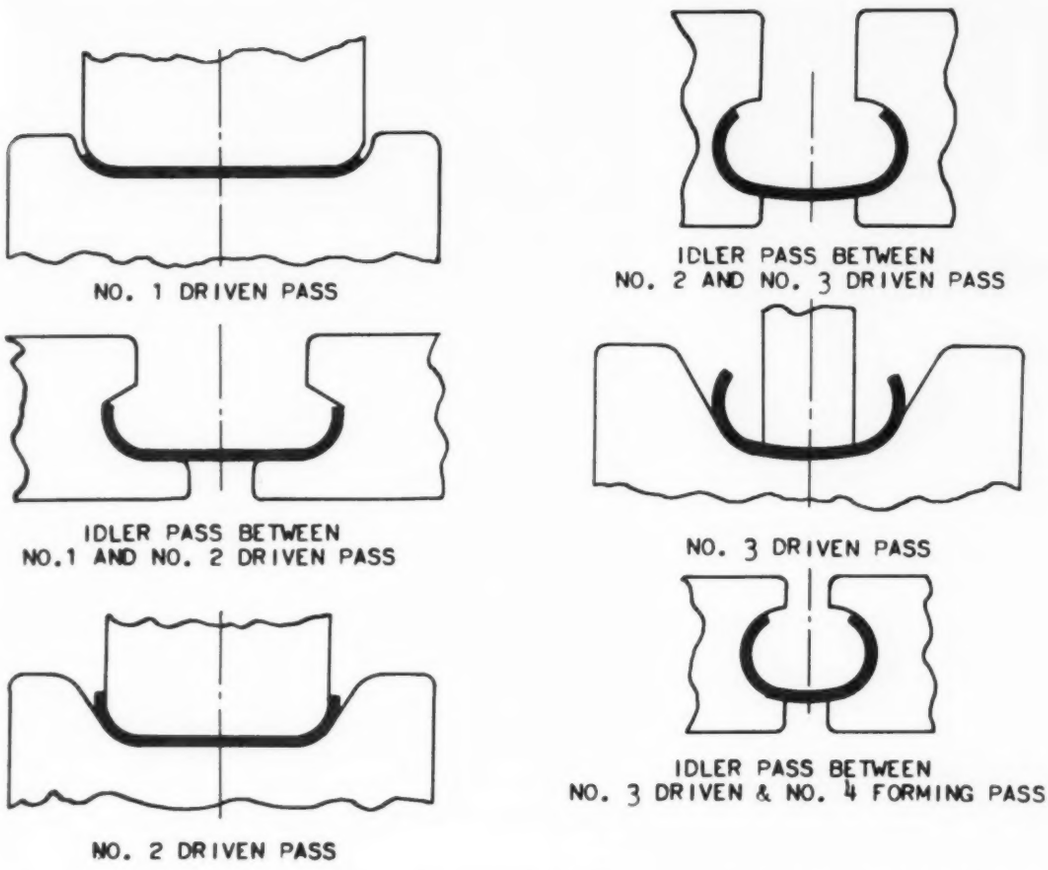
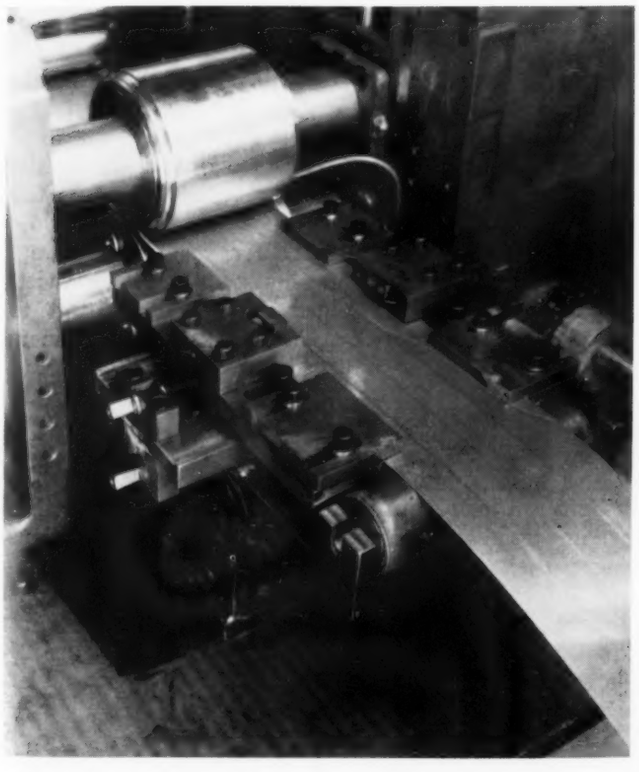

NO. 1 DRIVEN PASS
IDLER PASS BETWEEN
NO.1 AND NO. 2 DRIVEN PASS
NO. 2 DRIVEN PASS
IDLER PASS BETWEEN
NO. 2 AND NO. 3 DRIVEN PASS
NO. 3 DRIVEN PASS
IDLER PASS BETWEEN
NO. 3 DRIVEN & NO. 4 FORMING PASS

Figure 20 — Where springback is a major problem, progressive forming may be necessary.

horizontal deflection of the strip in its passage between rolls; and (3) to prevent twisting and curving of the shape as it leaves the machine. Recommended forming practice is to use the minimum number of guides necessary since each guide represents a possible source of scoring and pickup.

Figure 21 — This is an entrance table for guiding stock into a forming machine.



It is important to bear in mind that guides are mainly intended for guiding the metal and not for correcting inaccuracies in roll setup and alinement. Buckling or waviness in the finished section frequently results from disregarding this fact.

In all cases where coiled or cut-to-length strips are to be formed, it is necessary to use either starting bar guides or roll guides to lead the strip into the first roll pass. These guides maintain the strip of metal in the correct horizontal and vertical alinement with the first pair of forming rolls. The roll guides consist of a pair of rolls, one on each side of the strip, and the bar guides, a bar on each side with a groove or step on the inside faces to hold the strip. Both types of guides are adjustable horizontally in or out, either separately or together, by means of a double-screw arrangement. Figure 21 shows the use of bar guides installed at the feed end of a roll forming machine.

Guides, like the main rolls, are machined from various kinds of metals, depending upon the kind of metal being formed and the desired length of service. The wearing qualities of the guide metal and the relative friction between it and the metal being formed are of primary consideration. Thus, bronze is usually chosen when forming steel, and hardened steel is chosen when forming brass or other nonferrous metals.

IDLER ROLLS

Idler rolls are so called because, unlike the main rolls, they are not power driven. They are, however, designed to do a certain amount of forming, supplementing that done by the main rolls. They are especially useful in the forming of curved or recessed contours

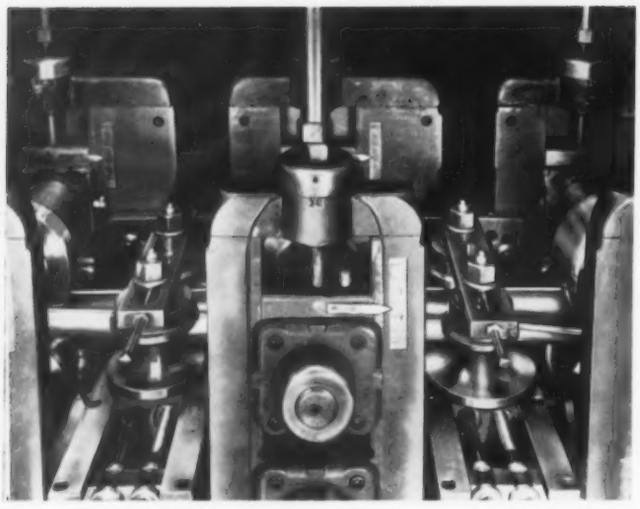


Figure 22 — Idler rolls are mounted so as to apply pressure from the sides during the forming of a tubular section.

in a vertical plane. To this end, idler rolls generally rotate on a vertical axis, and are adjustable mainly in the horizontal plane—just the opposite of the main rolls.

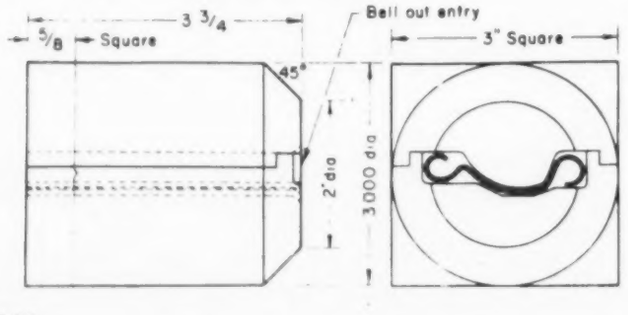
An idler roll support is similar in shape to a guide support, and is attached to the machine base and spindle housing in the same manner. Spindles for the idler rolls are mounted in bearing blocks which can be positioned on the support to accommodate different roll sizes. In Figure 22 are shown two pairs of idler rolls mounted on adjustable supports between two successive roll passes, in a setup for forming lock-seam tubing.

By using idler rolls for auxiliary forming in the horizontal plane, the amount of work that has to be done by the main rolls may be reduced. When idler rolls are required, usually one or two pairs will be sufficient.

STRAIGHTENERS

Slight curving or twisting can be compensated for with a straightening device. This device can be either a roller or a guide type, whichever is best suited for the job. It must be adjustable vertically and horizontally and must be rotatable in order to produce a shape as nearly straight as possible. It must also be mounted as close as possible to the exit side of the last roll pass. Figure 23 shows a simple but effective straightener guide for the slat shape shown in Figures 12 through 16. The mounting of this block can vary, depending on

Figure 23 — Guide type straightener for roller curtain door slat illustrated in Figures 12 through 16.



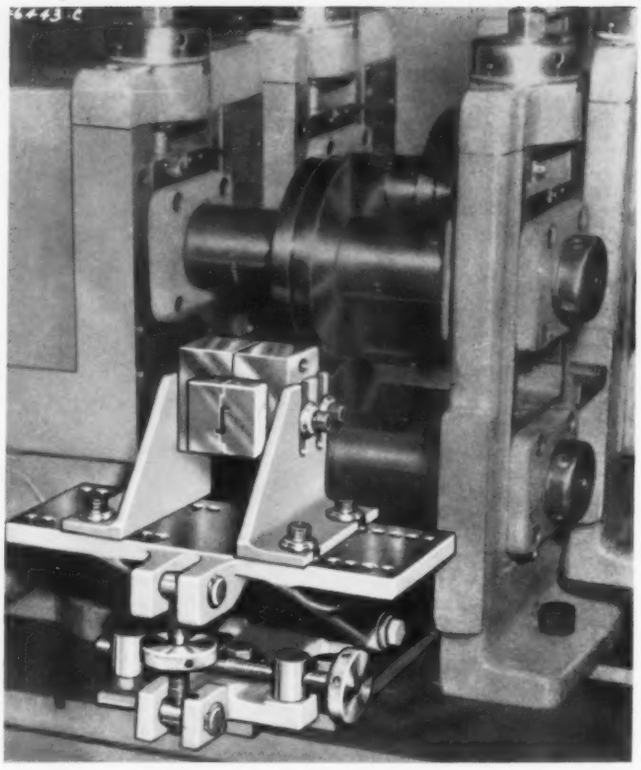


Figure 24 — This is a typical straightener mounted on an adjustable table at exit end of a forming machine.

the machine it is mounted on, but must be universally and conveniently adjustable.

One type of straightener, shown in Figure 24, consists of a table on which the different straightening guides may be mounted as required. The table pivots vertically on the base, so that if the finished shape tends to bend up or down, the table can be tilted in the opposite direction. The base of the table swivels on a single vertical bolt and can be moved left or right to offset any tendency of the strip to bend in the horizontal plane.

The straightening guide, which, of course, has to be made to fit each different shape to be produced, is made of two blocks, clamped longitudinally in a fixed position. The guide may be turned on its axis in the clamp block so as to counteract any twist in the finished section.

Wide sheets, such as are used for roofing and siding, do not require straightening horizontally or for twist. A pair of simple flat guides is usually sufficient to prevent curving up or down. Roller type straighteners are used sometimes, but they are not adaptable to all shapes.

AUXILIARY OPERATIONS

Cold roll forming machines may be equipped with a bending stand at the outfeed end, on which various yokes or shoes can be fastened. These can apply deliberate coiling to the finished section. If coiling is desired, adjustable coiling rolls designed either as idlers or as driven rolls can be provided. Figure 25 shows the use of special idler rolls to form a circular section.

Cold roll formed sections to serve their final purposes

must generally have other production operations performed on them. Many of these operations, such as piercing, slotting, trimming, embossing, numbering and printing, can be incorporated into the roll form tooling. In general, these operations are performed with roll located ahead of the first forming pass. Piercing or slotting punches for light gage materials are frequently mounted on a "male" roll, and the dies on a "female" roll. The roller dies are designed to punch the slugs completely through the metal strip. The designer must position such holes in even divisions of the circumferences of the roll pitch diameters. They may be arranged in almost any order within the capacity of the roll diameters.

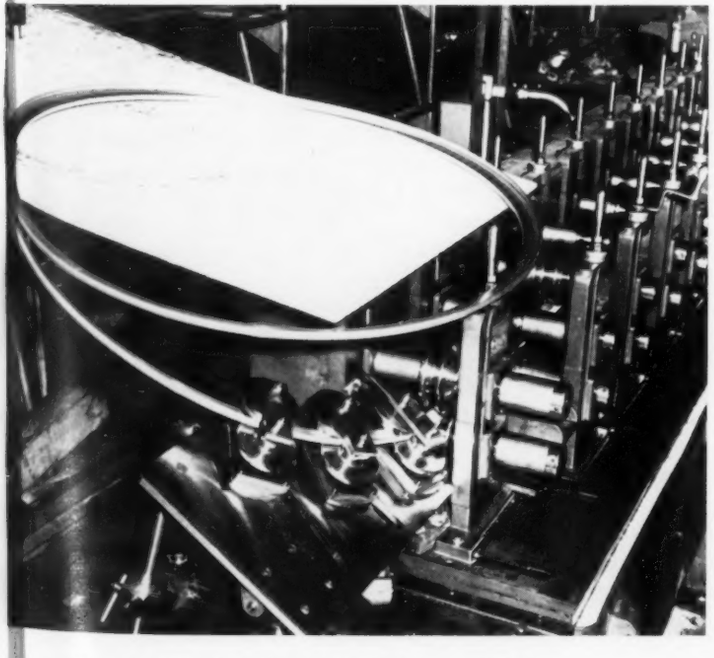
Metal strip can be embossed with decorative designs and functional markings at no increase in tooling cost except the additional expense of milling or engraving the pattern on one pair of forming rolls.

If the strip has to be embossed over its entire width, the embossing must be done on the flat strip, usually in the first pair of rolls; in cases where only part of the strip width has to be embossed over a relatively flat area, the operation may also be done in the first roll pass. Where a sharp pattern of considerable depth is required over a relatively flat area, however, the embossing rolls are placed next to the exit of the machine to avoid flattening of the design by subsequent forming pressure. Picture molding and automobile scuff plates are familiar examples of this type of embossing operations.

Strip may also be indented or marked at regular intervals for the positioning of tacks or nails or to facilitate installation.

When it is desirable to identify the section being rolled by marking with ink, the operation may be performed at either the feed or exit end of the machine. If inking rolls are used at the feed end, the ink must be of the quick-drying type to prevent smearing by the lubricant. An air hose attached to the machine helps dry the ink before entering the first forming pass.

Figure 25 — Roll type coiler is mounted on adjustable table at exit end of forming machine.



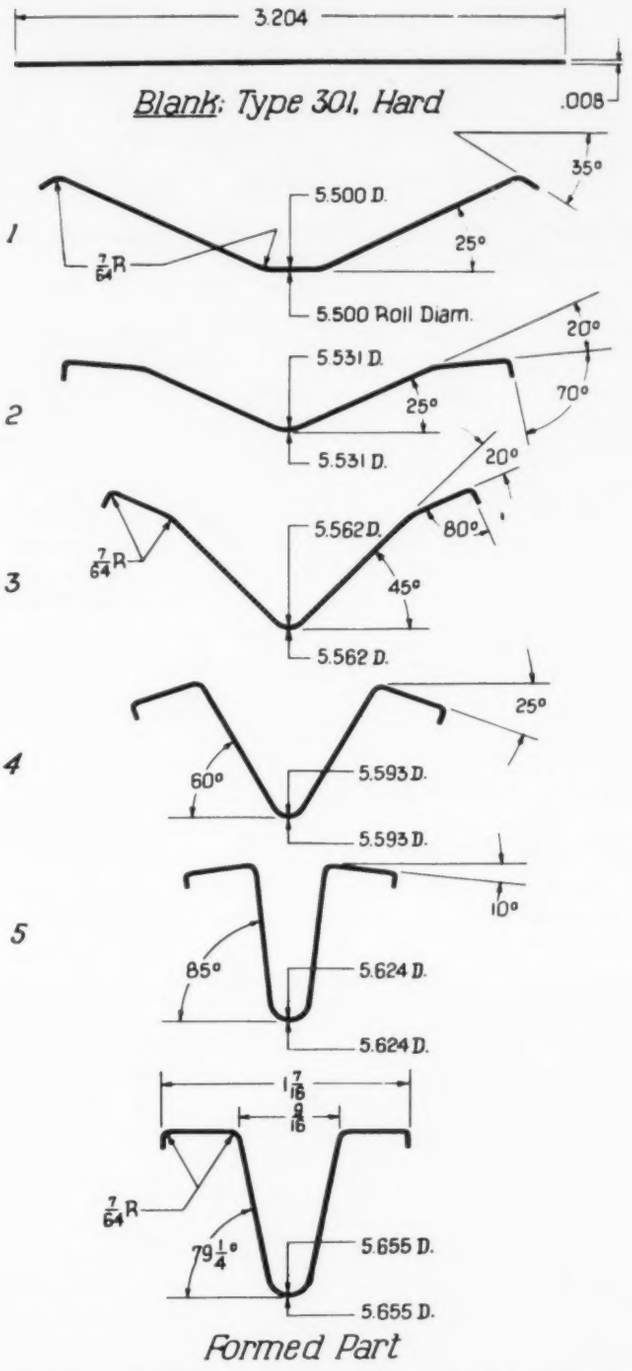


Figure 26 — Progressive forming of a stainless steel section illustrates the use of overforming to reduce springback.

TOLERANCES IN ROLL FORMING

Tolerances which can usually be held in the average roll formed section are the following:

Piece length.....	±1/16 to 1/64 in. using automatic cutoff. (Tolerance depends upon speed of operation and length of pieces.)
Twist.....	Slight, except where twist can be corrected with light hand pressure.
Cross-section dimensions.....	Fractional dimensions—±1/32

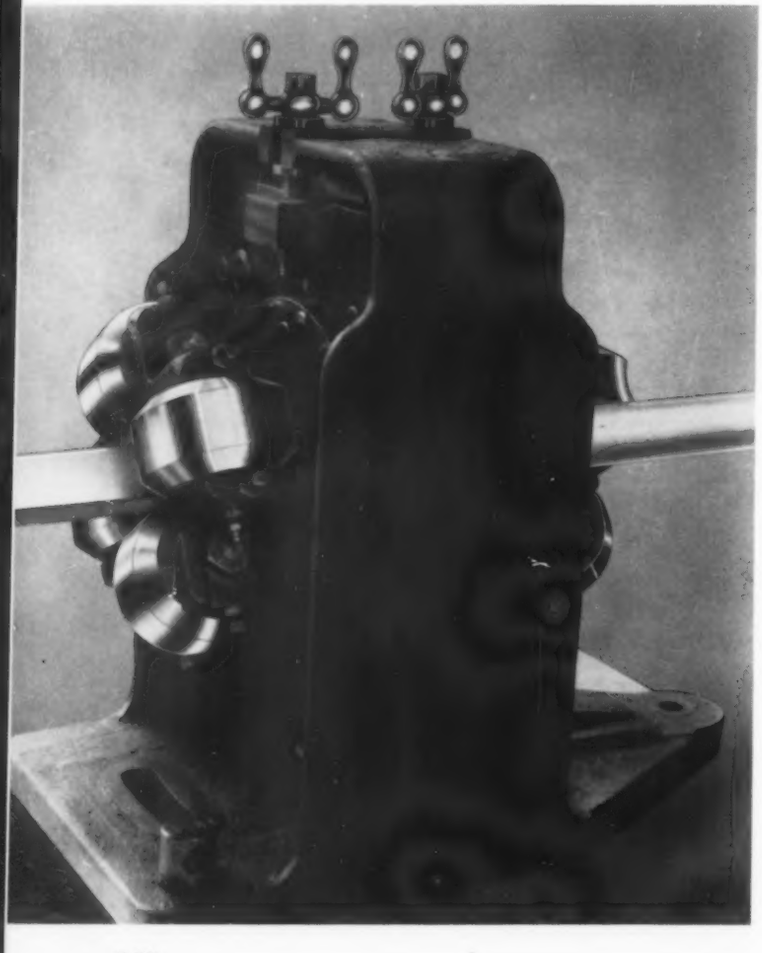
Figure 27 — These shapes are made from round lock seam tubing with a special rolling head.

	to 1/64 in. Decimal dimensions—±0.015 in. to 0.005 in. (depends upon gage tolerances of material).
Angles.....	±1 to 2 degrees depending on variations in material.
Straightness.....	Approximately 1/8 to 1/4 in. in 10 ft.

SPRINGBACK

Springback is encountered to a varying degree, depending upon the design of the section, the properties of the metal and the method of forming. For most materials it may generally be eliminated by slightly overbending in the next-to-last pass. While the roll design for soft stainless steels does not materially differ from that for low carbon steels, the high springback of the harder tempers of stainless steel necessitates special measures (9). Figure 26 shows the progressive shapes in the forming of a hard stainless steel strip 0.008 in. thickness. It will be noted that each right angle corner is overbent by five to 15 degrees and then formed to a right angle in subsequent passes. Within these limits of overbending the springback can then be adjusted to the desired amount by regulating the roll pressure.

Figure 28 — This head is for forming special shapes from round tubing or pipe.



LUBRICANTS

Among the numerous lubricants for roll forming is soluble oil diluted with water, anywhere between 2 per cent (50 to 1) and 10 per cent (10 to 1) is widely used. These dilute solutions are easily removed.

The roll forming of stainless steels necessitates special consideration of lubricants used because of the importance of surface finish. New detergent and wax type lubricants are now available and are being used with good results. Other efficient lubricants, such as a 10 per cent soap solution, or even an extreme pressure oil, are valuable in reducing roll wear and in producing a high finish, even though they are somewhat more difficult to remove. Where a deep part or a complex shape causes marked differences in roll radii which are not compensated for by unequal gearing, an extreme lubricant such as a viscous sulphurized-chlorinated fatty oil may be needed to minimize scuffing (9).

REFORMING LOCK-SEAM TUBING

An interesting adaptation in cold roll forming is the forming of shapes with special closed cross sections (13). First, a round lock-seam tube is rolled. Then a special rolling head converts the circumference to the periphery of the cross section desired such as those shown in Figure 27.

This method is particularly advantageous if several closed shapes of different configurations are designed to have the same developed width or "stretch-out." The initial tooling expense is considerably reduced by having only one set of main rolls to form a tube and separate special head rolls, such as that shown in Figure 28, to convert the tube into the desired shape.

The process is limited to comparatively shallow bends and sections without sharp radii or deep grooves. The special rolling head is set up similar to a regular roll pass and is simply a housing containing rolls for forming both in horizontal and vertical directions and combinations of each. This head is also designed for use as a tube straightener.

Figure 29 shows several types of joints commonly used for formed tubing.

SUMMARY

The recent growth in the manufacture of products by the roll forming process has been very great, and it is probable that use of the process will continue to grow at a rapid rate. In the construction industry this future expansion in the use of cold roll forming is well substantiated by the expanding use of structural members and structural panels formed from sheet and strip steels (of both the carbon and high strength, low alloy types). The popularity of light weight exterior curtain walls of both porcelain enameled and stainless steel, and such building components as formed steel partitions and

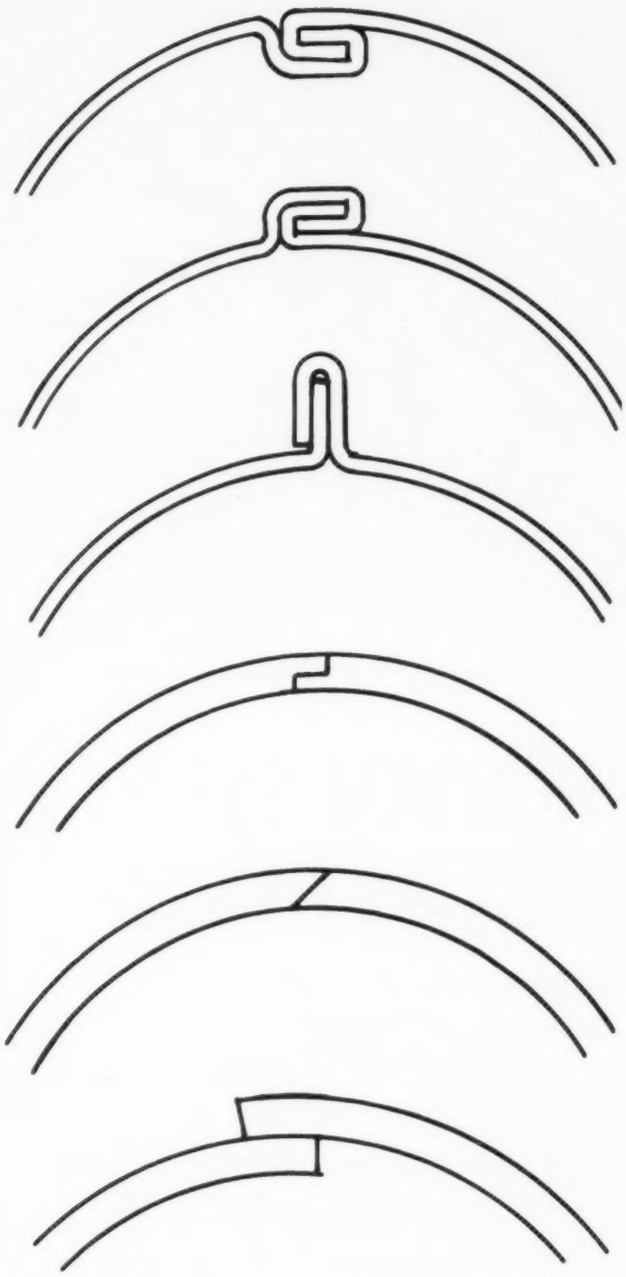


Figure 29 — Types of seams used for nonwelded tubing.

stainless steel window mullions and trim is further justification for this conclusion.

In recognition of the expanding future in the use of structural members formed from light gage steel and strip and the fact that design specifications applicable to the commonly used hot-rolled structural elements were not fully applicable to structural members formed from light gage steel, the American Iron and Steel Institute through its Committee on Building Research and Technology, instituted a research program in 1939 for the purpose of developing factual information on which to base a design code for this type of construction. This research undertaking has been carried out continuously since 1939. Based upon its findings and upon rapidly accumulating practical experience, the first edition of the Specification for the Design of Light Gage Steel Structural Members was issued by AISI in 1946. Additional research data and developing practices in the use of light gage cold formed steel structural elements have been incorporated in a second revised and enlarged edition of the manual published in 1956. The 1956 edition of the Specification for the Design of Light Gage Cold-Formed Steel Structural Members, published by AISI is accepted throughout the United States as the standard for the design of structural members formed from light gage sheet and strip steel.

It is important that research on the design and use of cold formed steel products be continued where necessary to fill in any gaps in the present knowledge concerning such products. Only through such continued research can the advantages of cold roll forming be utilized to their maximum.

In recognition of the need for the dissemination of present information regarding structural uses for formed steel products; to furnish to the teacher and the student background material for a study of light gage steel design methods, to provide a record of the reasoning behind and justification for the various provisions of the above described specification, and to offer to the interested structural engineer a brief but coherent presentation of the characteristics and performance of thin-walled steel structures, AISI has recently published a commentary on the 1956 edition of the "Light Gage Cold-Formed Steel Design Manual." It is expected that by use of the design manual and the commentary in engineering schools throughout the United States that engineering students will better obtain an appreciation of the potential advantages which can frequently be obtained by the use of formed steel products. The continued development of such interests can have no other than a stimulating influence upon the roll forming industry in the future.

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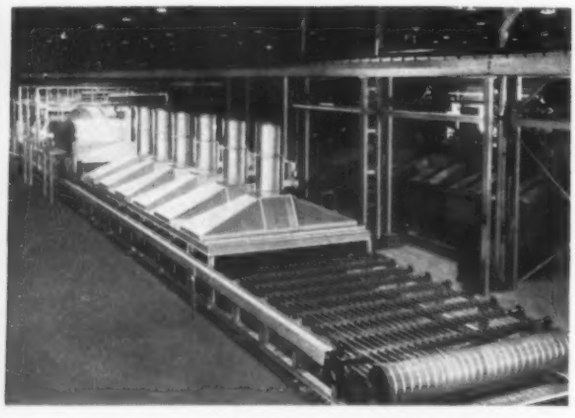
Charging end of Rust aluminum sheet, annealing furnace (one of two) for Reynolds Metals Company. Over-all length is 175', with 12' inside width.

ALUMINUM SHEET ANNEALING FURNACE

with new type of band conveyor designed and constructed for Reynolds Metals Company, Listerhill, Alabama.



Discharge end of annealing furnace. A new type band conveyor minimizes the marking of the aluminum sheets.

This modern Rust furnace is designed to anneal hourly 12,000 lbs. of aluminum sheets, 0.01″ to 0.25″ thickness in random sizes up to 144″ wide. A new type of band conveyor minimizes (often completely eliminates) marking of the aluminum sheets by the furnace conveyor. Individually tensioned stainless steel bands are spaced to accommodate a variety of sizes and shapes of aluminum products.

Heating is accomplished with 100% forced convection. Massive volumes of recirculated gases maintain the customary requirement of ±5° F in a temperature range of 325° F to 950° F (determined by alloy and heat treatment desired) for the heaviest loads.

Reduced rates of recirculation provide the same temperature uniformity for lighter loads and prevent whipping of lighter gauge aluminum sheets.

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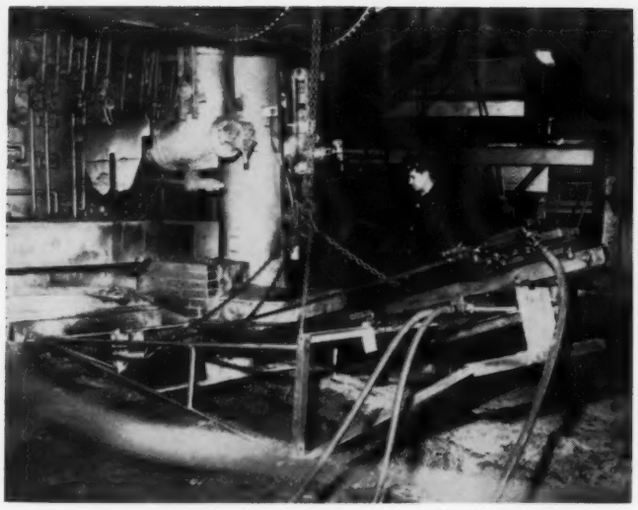


Figure 1 — CF&I's new method uses this converted coal drilling rig. The rig, guided by a rack, makes for safer and more efficient drilling.

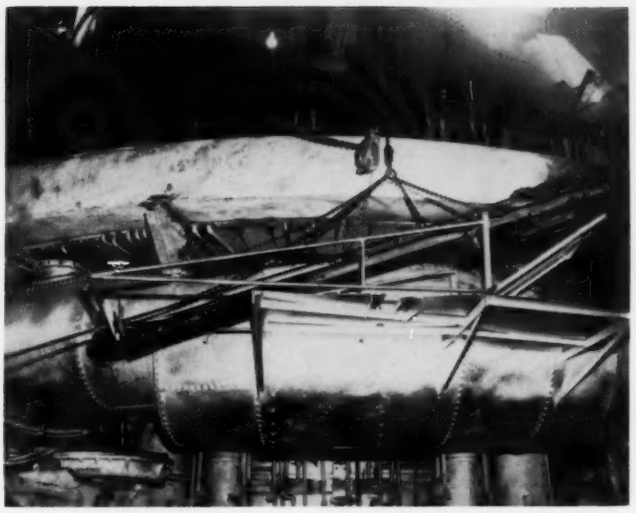


Figure 2 — In storage, the rig assembly rests on top of the bustle pipe support. It is lifted there by an electrical trolley.

Rig Drills Blast Furnace Tap Holes

BLAST furnace workers at The Colorado Fuel and Iron Corp.'s Pueblo, Colo., plant, have developed a new, far safer method of drilling blast furnace tap holes. The ingenious CF&I steelworkers have put a converted coal drilling rig to work making the tap holes. By replacing manual drilling of the clay plug which seals the furnace, the coal drilling rig enables the men in charge of the tapping to operate from a safer distance. With the coal rig doing the drilling, the workers can stand well out of reach of the sparks and beads of hot metal that blow out of the hole when the drill breaks through the hearth and into the molten iron.

The drill itself consists of a jackhammer that travels on a 12-ft chain drive feedshell which is powered by an air motor. A special rack designed by the Pueblo plant's blast furnace department guides the drill into the hole as the motor is turned on and the jackhammer is propelled forward by the chain drive.

After the tap hole has been drilled, the drill assembly is lifted off the floor by an electrical hoist and moved along a trolley onto the bustle pipe where it is stored until needed again. ▲

AISE Forms Colorado Section

THE AISE board of directors at their meeting in September approved a petition for the establishment of the Colorado District Section of the AISE. The new section is split from the Utah section and includes primarily the area of Colorado. Personnel from the Colorado Fuel and Iron Corp. have been influential in setting up this new group which has been meeting as a subsection for the past two years.

As a result of this activity, the membership grew sufficiently in this area to warrant a new section. Some of the members active in this formation have been Frank Argust, superintendent of industrial engineering dept., CF&I, J. L. Lindberg, assistant to director of mechanical maintenance dept., CF&I, and H. V. Gumma, assistant superintendent rolling mills & finishing dept., CF&I. The latter is chairman and Mr. Lindberg is assistant chairman of the section. W. B. Hamlin, industrial engineer, CF&I, is acting secretary of the section. Initial guidance of the section will come from an executive committee consisting of William Brill, director of engineering, H. E. Watson, superintendent of electrical dept., G. R. Morgan, senior industrial engineer, and F. F. Argust, superintendent of industrial engineering dept., all of the Colorado Fuel and Iron Corp.

The meetings for the current year will be held every month from September, 1959 through June, 1960. Home base for the meetings is at the Minnequa University Club, Pueblo, Colo., on the third Tuesday of each month with a social hour beginning at 6:30 p.m. and dinner at 7:00 p.m., with the meeting itself at 8:00 p.m. One meeting in June will be a joint meeting with the Utah district section at Glenwood Springs, Colo. An excellent program has been lined up for the current year.

TC&I Feeds Tin And Black Plate Mechanically

THE Tennessee Coal & Iron Division of the United States Steel Corp., Fairfield, Ala., mechanically feeds tin and black plate to slitters, oiling machines, sheet counters and tin pots.

It currently feeds six slitters mechanically, using metal sheet feeders manufactured by The Dexter Company Division of Miehle-Goss-Dexter, Inc., Pearl River, N. Y., and will soon change over one more hand-fed machine to automatic feeding.

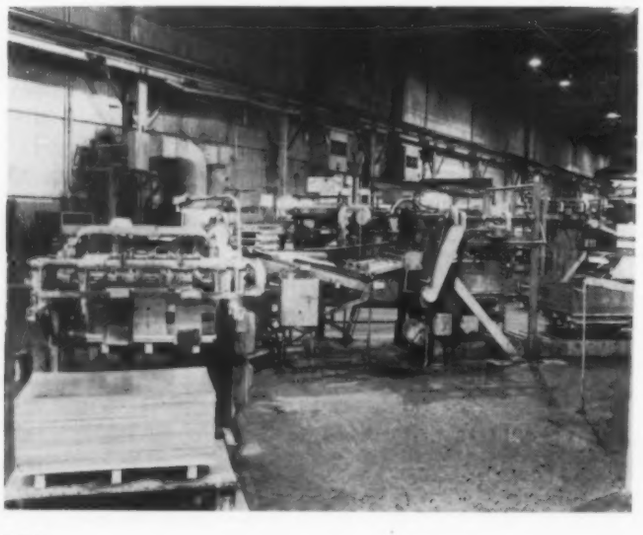
The company has designed three Dexter-fed machines for applying oil to black plate to prevent rust. It is believed that this is the only completely mechanical operation of its type.

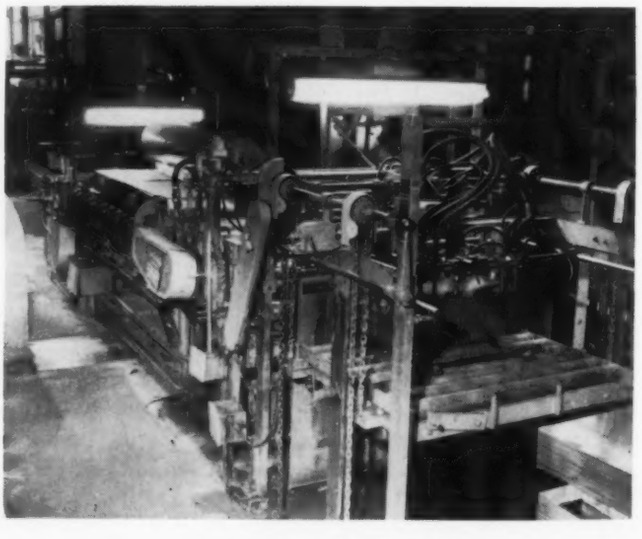
Certain tin mill operations leave stacked sheets in an uncounted condition and TC&I has devised its own automatic sheet counter to eliminate inaccuracies of hand counting. The first automatic counter was so successful that a second is now being installed.

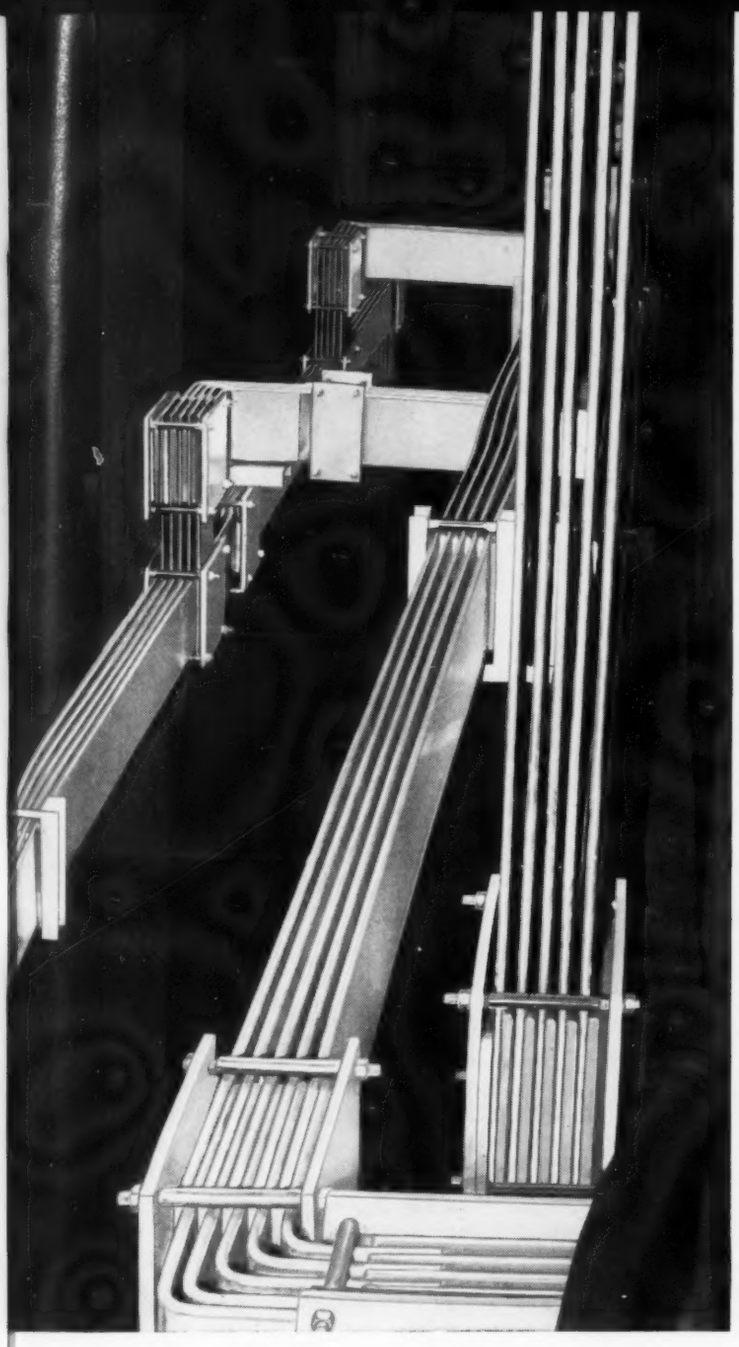
Sheet-fed tin lines have long been fed by automatic feeders. Each line is equipped with a Dexter feeder capable of handling two or three sheets simultaneously. Tennessee Coal & Iron has 16 such tin lines.

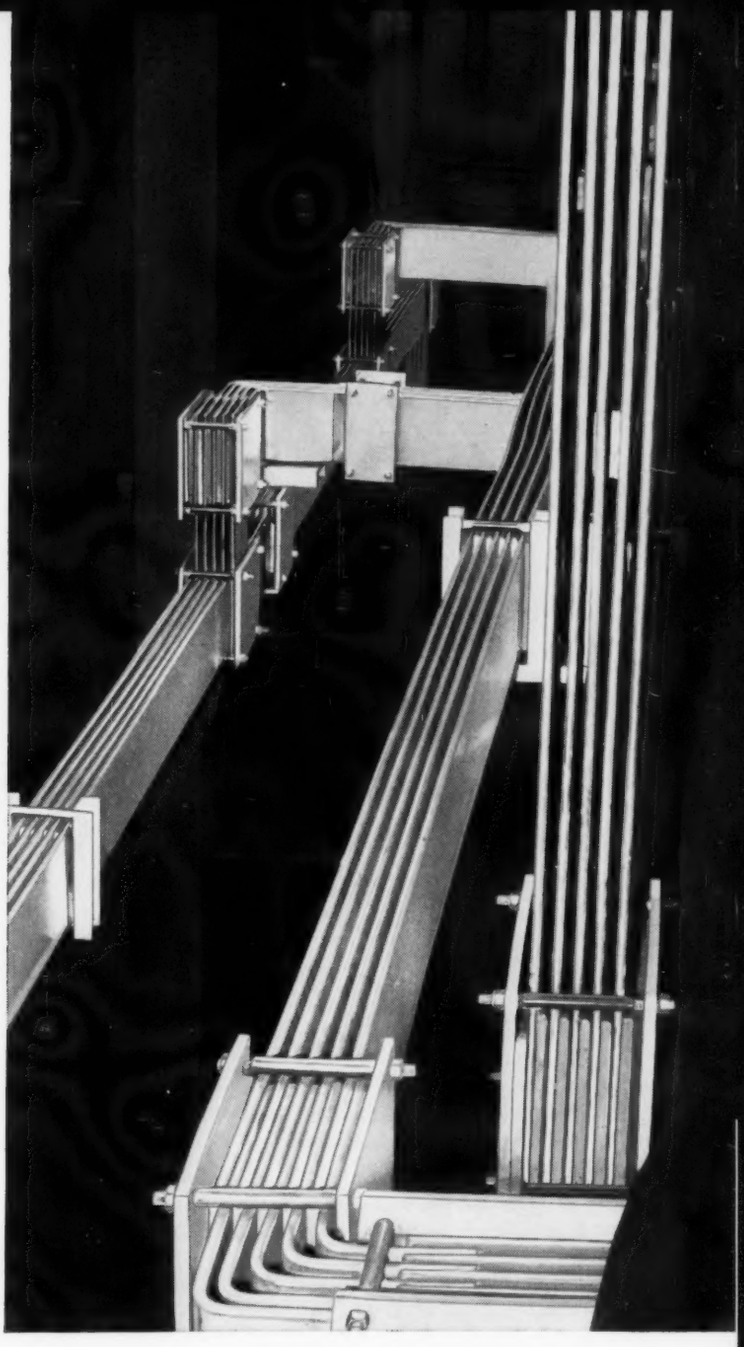
Slitters—In automatically feeding slitters (Figure 1), bundles weighing in the neighborhood of 3500 lb are brought to the feeder by an overhead crane and positioned on a stand-by roller conveyor for loading onto the feeder's elevator platform. When the preceding bundle has been fed off, the elevator platform is lowered, the empty pallet is removed and the new bundle rolled into place. The elevator then lifts the load to feeding position whereupon an automatic pile height governor takes over and indexes the load

Figure 1 (left) — Stacks of tin and black plate are brought to the feeder by crane, loaded onto its elevator-platform, and fed automatically to slitter. TC&I has equipped six slitters in this manner. Figure 2 (right) — Sheets are mechanically fed beneath a reciprocating pipe which sprays them with a mixture of naptha and oil. Naptha is subsequently evaporated in short drying oven. Three such machines eliminate manual brushing operation.









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ALCOA ALUMINUM

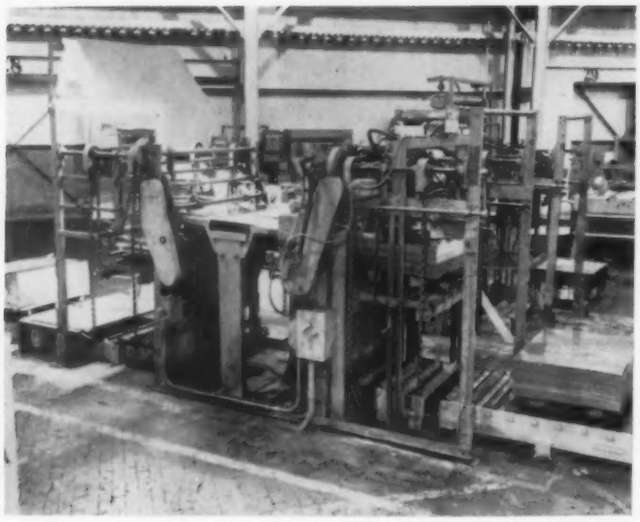


Figure 3 — Sheets are fed from pile to conveyor which carries them through photo-electric counter and delivers them to piler for restacking. Second counter is now being built and has late model, high speed, feeder.

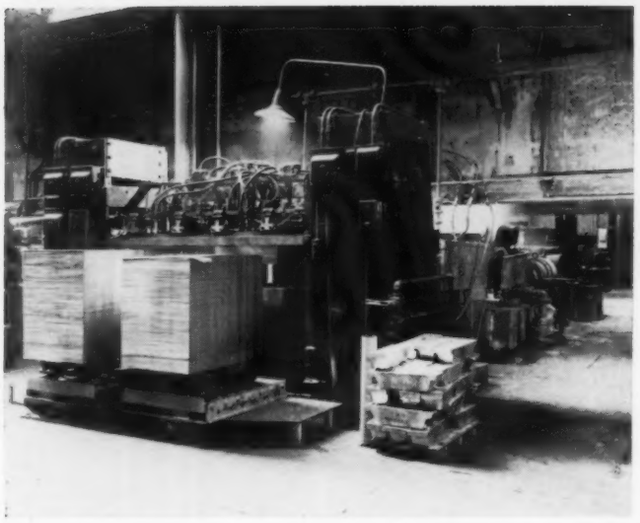


Figure 4 — One of sixteen tin lines, each of which tins two or three sheets simultaneously. Near-6000-lb bundles are stacked on structural supports resting on pipe-pallets for movement along rollers of standby conveyor and feeder elevator-platform.

upward as sheets are fed off. In feeding a sheet, suction cups lift the rear edge and a blast of air is blown between it and the pile to complete separation. Suction cups near the front edge then lift and pivot, advancing the sheet between friction rollers which deliver it to the slitter conveyor. When a load has been depleted, the elevator is again lowered for reloading.

All but one slitter are in tandem units and trim two opposite edges at one station and the other two edges at the remaining station. The second station also may be used in slitting sheets into two or more. The single-station machine trims two edges only and may also be used for slitting. Slitters trim 78 sheets per minute. The Dexter feeders were originally equipped with mechanisms which would reject double-fed sheets; however, there was no call for these units and they are no longer used.

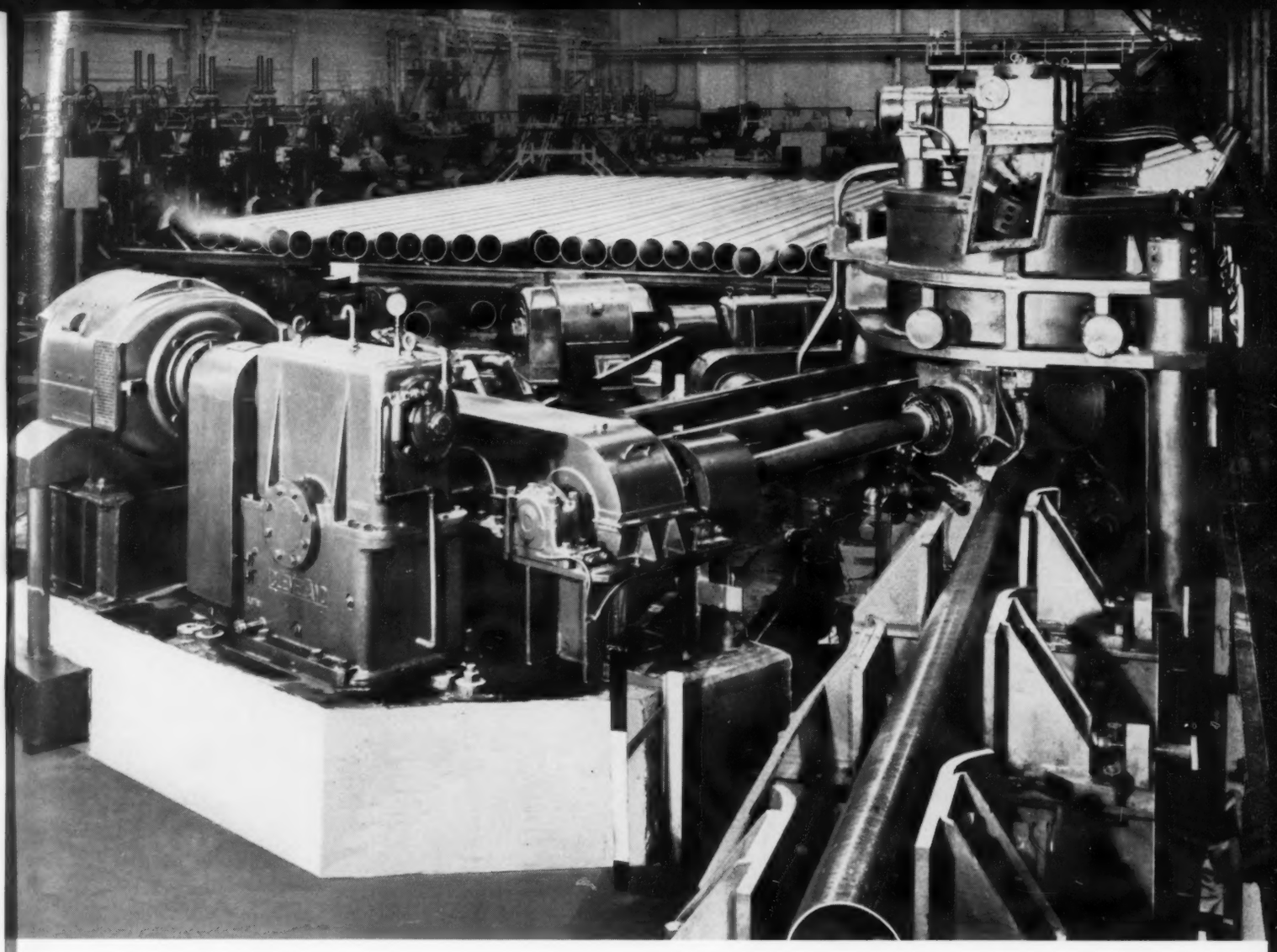
Oiling machine—TC&I's own unique method for oiling black plate (Figure 2) comprises a Dexter feeder, oiling unit and drying oven. The feeder operates as previously described and delivers sheets to a live-roll conveyor which conveys them through the oiling unit and dryer. A reciprocating spray pipe moves back and forth across the sheets as they emerge from the feeder, spraying them with a mixture of oil and naptha. The naptha increases the spreading power of the oil and assures that it covers the entire sheet. The naptha is then evaporated in a short drying oven and fumes are exhausted to atmosphere.

Bundles are brought to oiling machine locations by the crane and deposited in temporary storage on wood blocks so that they can be picked up by industrial trucks or by the crane for placement on the stand-by conveyor. Special carriers support the loads when on the roller conveyor and feeder platform. These rectangular carriers are constructed of four pipes, welded at the corners, two on top of the others. This construction provides a sturdy, lightweight carrier which enables the heavy loads to be conveyed smoothly along the roller conveyor and platform. Blocks are placed across the pipes and the load deposited on the blocks. To reduce loading time, one bundle is placed atop another, and when one bundle is fed off, instead of lowering the platform for the next load, the blocks separating the two bundles are simply removed and feeding continues.

Counting machines—The counting machine (Figure 3) is made up of a feeder, photo-electric counter and piler. Sheets are fed to the counter, electronically counted, and delivered to the piler. Operation of the counter has justified a second unit, now under erection. The new counter will be equipped with a late-model feeder capable of delivering up to 150 sheets per minute and supporting loads to 9000 lb. Present feeders generally deliver less than 100 sheets per minute and support loads up to 6000 lb. The higher load capacities enable the machines to run longer between loadings. The piler operates in reverse of the feeder, indexing the load downward as it accumulates sheets.

Tin lines—Each tin line is equipped with feeders capable of feeding two or three sheets to the tin pots simultaneously (Figure 4), so that each pot may be used to full capacity. Feeders operate as previously described but each machine has duplicate or triplicate sets of feeding mechanisms, all operated simultaneously from the same source. Each group of feeding mechanisms is serviced by individual elevator platforms and standby conveyors. Plate is stacked considerably higher in this department, each bundle weighing nearly 6000 lb, and is handled entirely by industrial truck. The higher stacks, of course, reduce the number of loading operations, and result in greater production.

In considering automatic feeding, cost, speed and human engineering factors are important. Today's high labor costs, high-speed production machines, enlightened attitudes toward labor, and reduced manpower availability are currently demanding mechanization of many operations, such as automatic machine feeding, in many applications which could not have been economically mechanized a few short years ago. ▲



How to straighten the really big pipe!

One major Eastern steel producer has found the answer – the big Mack-Hemp Model A-5 Straightener shown above – the largest of its type in the world!

This A-5 takes really big bowed pipe from the sizing mill, pulls it in through three pairs of opposed cross rolls and then spins it out straight and round to high tolerances in only a single pass.

This despite the fact that the steel pipe being straightened is 16-inch in diameter, fifty feet in length!

To do a job like this, of course, the massive 85-ton roll frame is a must, as are the heavy duty rolls, and the combined 200 HP motors used to drive all six of them. In its first year, this Mack-Hemp A-5 straightener has handled more than 200,000 tons of pipe.

If straightening pipe or tubing is your problem – any size, any alloy – consider doing it yourself. The men from Mack-Hemp will be glad to give you all the facts you'll want to know.

MACKINTOSH-HEMPHILL
Division of E. W. BLISS Company
Pittsburgh and Midland, Pa.

MACKINTOSH-HEMPHILL DIVISION · PITTSBURGH-U.S.A. ·

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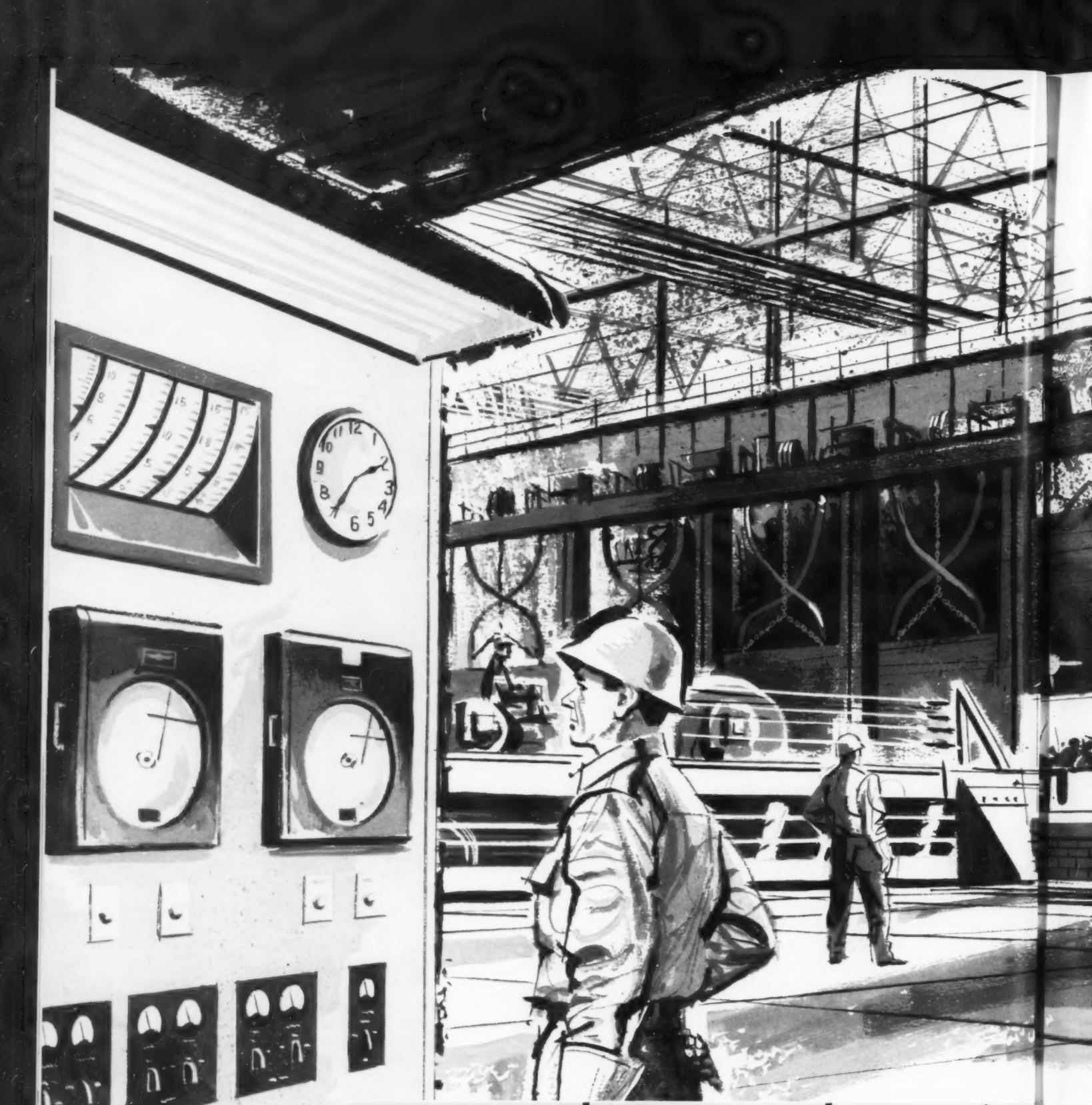
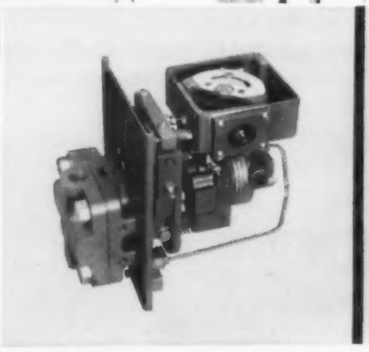
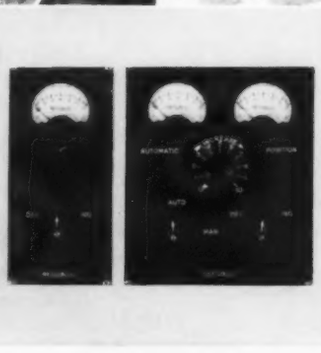




Republic VDP Differential Pressure Transmitter for oxygen and fuel/air flow measurement. VDP Transmitters belong to a new family of pneumatic instruments that use Republic's null-balance-vector principle.

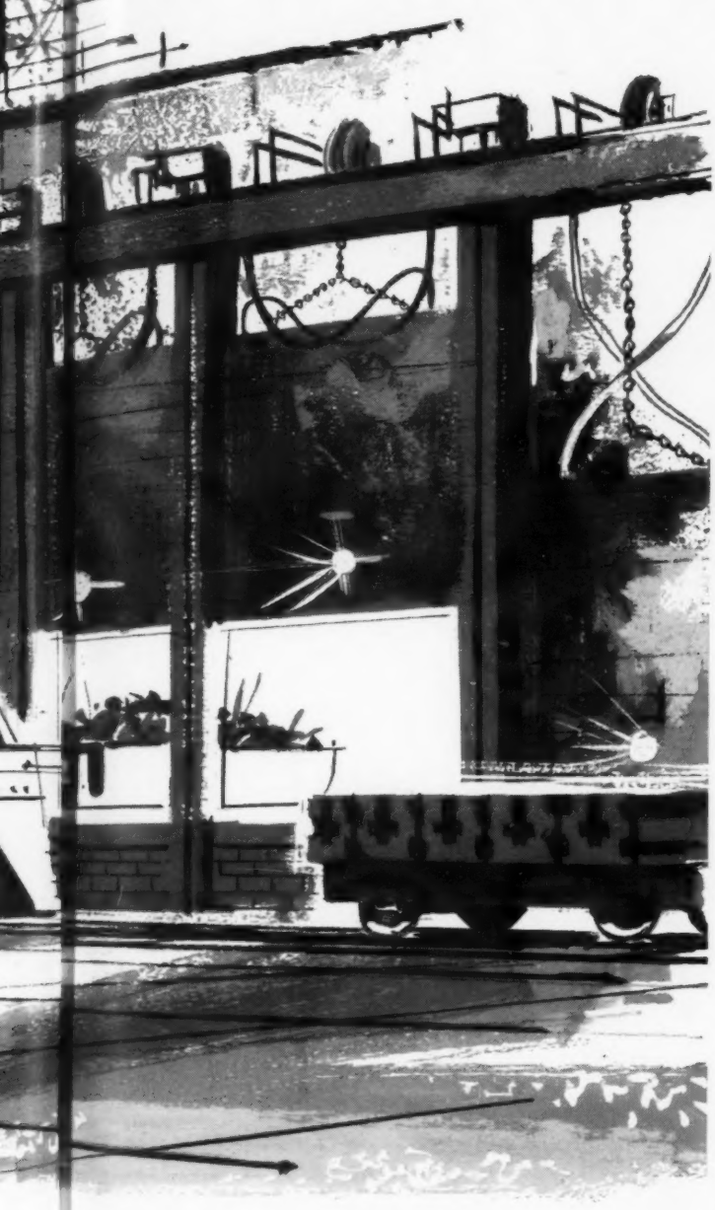


Complete electronic control systems are available for controlling the various functions in an open hearth furnace. Included are transmitters, totalizers, controllers and final drive units.

Republic Final Drive Units operate valves, damper, inlet vanes, etc., in response to air loading pressures or electronic loading signals. They can be controlled automatically or manually, remotely or locally.

From Republic Flow Meters . . .

Complete furnace control system engineering



Whether you are installing a new open-hearth furnace or remodeling an old one, Republic Flow Meters' complete Control Engineering Service gives you three important advantages:

—Because Republic furnishes a complete line of instruments, pneumatic and *electronic* control equipment, *you get* single-source service and responsibility from preliminary system design to start-up.

—Because Republic has been making significant contributions to steel mill control systems and equipment for over forty years, *you get* depth of experience plus up-to-the-minute product and system design.

—Because Republic has a nation-wide network of experienced field engineers, valuable installation supervision, final system adjustment and instruction of operating personnel are available to you.

COMPLETE LINE of Republic pneumatic and electronic equipment handles the recording, indicating and controlling functions for open-hearth fuel flow and pressure, air flow, furnace pressure and atomizing steam.

On this page are illustrated a few of the many Republic products designed into your open hearth system. Wherever accuracy of response and precise control are important in the production of steel, Republic products and experienced engineering service are available to meet your needs. For information on Republic's Control Engineering Service, contact the Republic representative nearest you, or write Republic Flow Meters Company, 2240 Diversey Parkway, Chicago 47, Illinois. In Canada: Republic Flow Meters Canada, Ltd., Toronto. Subsidiary of Rockwell Manufacturing Company.

REPUBLIC INSTRUMENTS AND CONTROLS
more fine products by
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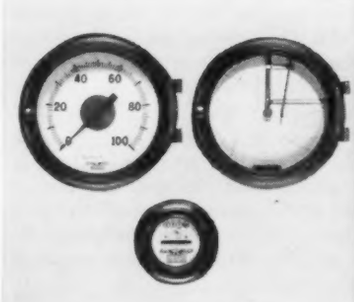
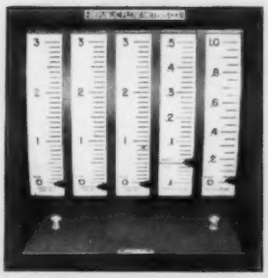
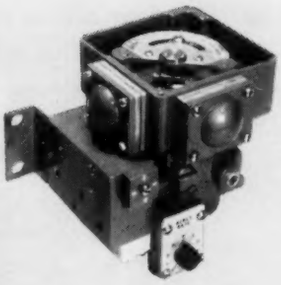


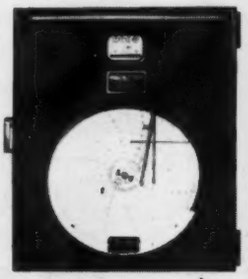
Republic-Pneumatic-electric flow meters for such applications as oxygen, dirty gases and heavy fuel oil measurements have continuous integration and remote electrical transmission.



Republic Multi-Point Indicators for drafts, pressures, flows and differentials, have large, easy-to-read scales. These multi-point indicators can be furnished for projected, flush or semi-flush mounting.



Republic VC Pneumatic Controller is an all-purpose null-balance-vector controller for use with any pneumatic transmitter for control of flow, pressure or temperature.



Republic Flow & Pressure Recorders register electrically, pneumatically or mechanically, are simple, compact units of sturdy construction.

Charging-Box Cars . . .

built to last by a company that uses them!

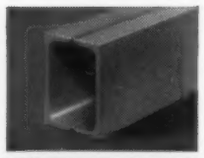
5 unique structural features make them better

Charging-box cars have to take a lot of punishment. And, in the 36 years we have been making charging-box cars for our own use, United States Steel has developed several features in structural design that assure longer life, less maintenance, and dependable service.

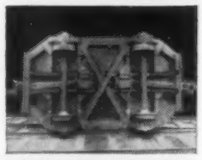
As illustrated in the typical four-box car shown here, the advantages of these design features—plus the rugged durability of all-welded *rolled* steel construction—make any size USS Charging-Box Car a profitable investment.

Our representatives will be pleased to call at your convenience to discuss your requirements for this or any other type of industrial car. Meanwhile, write for our free illustrated booklet—*USS Custom Designed Cars.* United States Steel Corporation, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

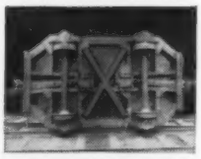
USS is a registered trademark



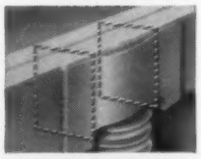
Box girder construction: Two channel sections, welded toe-to-toe, provide a frame far stronger than the ordinary angle or channel frame. This box frame is used under both the sides and ends of the car.



Double center sills: *Two* channels, back to back, run the entire length of the car. All cross members are welded to these sills, providing superior longitudinal rigidity.



X-frame bracing: These cross braces tie the box girder frame and the center sills together for additional strength and rigidity.



Spring pockets: Over each wheel, pockets are built into the bottom of the frame and "boxed in" on all sides. Coil springs are set into these pockets. This construction permits vertical, but no lateral, movement of the springs.

Long-shanked couplers: Pivot points of couplers are *behind* each axle. This permits turning the car on a short radius curve with less wheel flange pressure than with a short-shanked coupler.

USS

United States Steel Corporation—Pittsburgh
Columbia-Geneva Steel—San Francisco
Tennessee Coal & Iron—Fairfield, Alabama
United States Steel Export Company

United States Steel

National Steel Starts Operation of Plastic Coating Line for Strip

DEVELOPMENT of a process for bonding a highly decorative, abrasion-resistant plastic coating to long, continuous coils of strip steel was announced by Enamelstrip Corp., subsidiary of National Steel Corp.

Until now this type of predecorated metal product has been available to end-product manufacturers only in cut sheets, which involve costly handling procedures and material waste.

National Steel's new continuous coil predecorated steel will open up broad new areas of opportunity for hundreds of end-product industries to obtain higher standards of product quality and appearance at substantially lower production costs because:

1. In addition to being processed in continuous coil, it can be fed into end-product manufacturing equipment from long, continuous coils. This will eliminate hand feeding to production equipment, and no changes in existing tooling are required.

2. Despite being predecorated, it can be subjected to the same end-product forming operations as uncoated steel. This will free the manufacturer from having to subcontract or engage in painting and finishing operations.

3. The new steel can be predecorated in any pattern that can be photographed—any color, wood grains, leather, marble and other special effect patterns.

4. The decorative surface is protected by the full thickness of the transparent, polyester plastic coating. Tests of this coating in a 0.0003-in. thickness prove it 10 times more abrasion resistant than materials presently in use for table, cabinet and counter tops. It is also unaffected by most acids and chemicals, oxygen and industrial fumes.

Tradenamed Miracoil, the new predecorated steel is already being used successfully for cabinets by a major TV-set manufacturer.

Miracoil is presently in production in widths up to 32 in. New production facilities are being completed at Enamelstrip Corp. in Allentown, Pa., for making a 48-in. width available to the appliance industry before the end of 1959.

PROCESS

At the start of the production line, a coil of steel (previously inspected for weight, gage and hardness) is lift-trucked onto a coil ramp. This coil ramp feeds either one of two tandem uncoilers.

As the end of a coil already being processed nears, the starting end of the new coil is joined to it with a double-seam made by a stationary welder. Then the new coil of steel enters into a five tank washing, treating and drying section. Tank One is an alkali cleaner; Tank Two a hot water rinse; Tank Three a metal treating pressure spray and immersion; Tank Four a room-temperature water rinse; Tank Five a chromic acid rinse.

Equipment in this metal preparation section includes stainless steel jet nozzles and squeegee rolls located immediately following each tank. Solution heating, where necessary, is done by coil plate-type immersion heaters. Steam is the heat source.

Solutions are pumped to individual tank sections from 1000-gal tanks, equipped with dividers so that "return pumps" can push solutions in one side of a divider to the exit side of the tank where they are again pumped back into the metal preparation section. During this action, ample time elapses for settling and filtering.

Recording - control pyrometers control solution temperatures by activating solenoid valve controls at the temperature source. Solutions are titrated every 15 minutes, and detailed records kept of the findings.

From the five-tank metal preparation section, the coil travels through a vertical dryer where all traces of moisture are removed. Then it is ready for preheating prior to coating. This preheating is a key element in the overall process because it determines the ultimate bond and the quality and beauty of the coating's gloss and texture. In addition, it serves the function of partially curing the metal for coating "from the inside out."

In the meanwhile, the plastic coating is being preheated in heaters along the line. These heaters are located within 12 in. of the liquid-metal contact point. Rigidly controlled temperatures are maintained to insure coating under perfect viscosity control, and with the use of less solvent or volatile material.

The metal then goes into a composite, two-unit curing oven with a curing temperature of 300 to 600 F, depending on the gage of the metal and the speed of the processing operation. Just prior to being subjected to this "curing" the coil passed by two applicators which applied a coating to both sides of the metal at the same time. These coatings may have the same color and thickness, or different colors and thicknesses, depending on the customer's requirements.

On the decorative surface, a newly developed adhesive is applied, while the reverse side may get a protective or protective-decorative coating, again depending on the customer's specifications.

As the coil comes from the dual-oven, the protective coating on the reverse side has been cured. However, the adhesive-type coating on the decorative side is "tacky" in preparation for the application of a plastic decorative film. This film is fed from immediately below the dual-oven to pressure rolls.

This surfacing decorative film is a nonoriented, polyester type material. It may be used clear or as a printed film with any type decorative pattern that can be photographed. The final finish is dependent for color upon the pigmented adhesive applied earlier in the process.

As soon as the continuous coil leaves the pressure roller which has applied the plastic film, it passes into the cooling section. Here, the metal —from a temperature of about 350 F or higher—is cooled to a temperature just below freezing. This part of the process is also extremely important to the bonding and setting of the plastic surface and is the final operation in the process. ▲

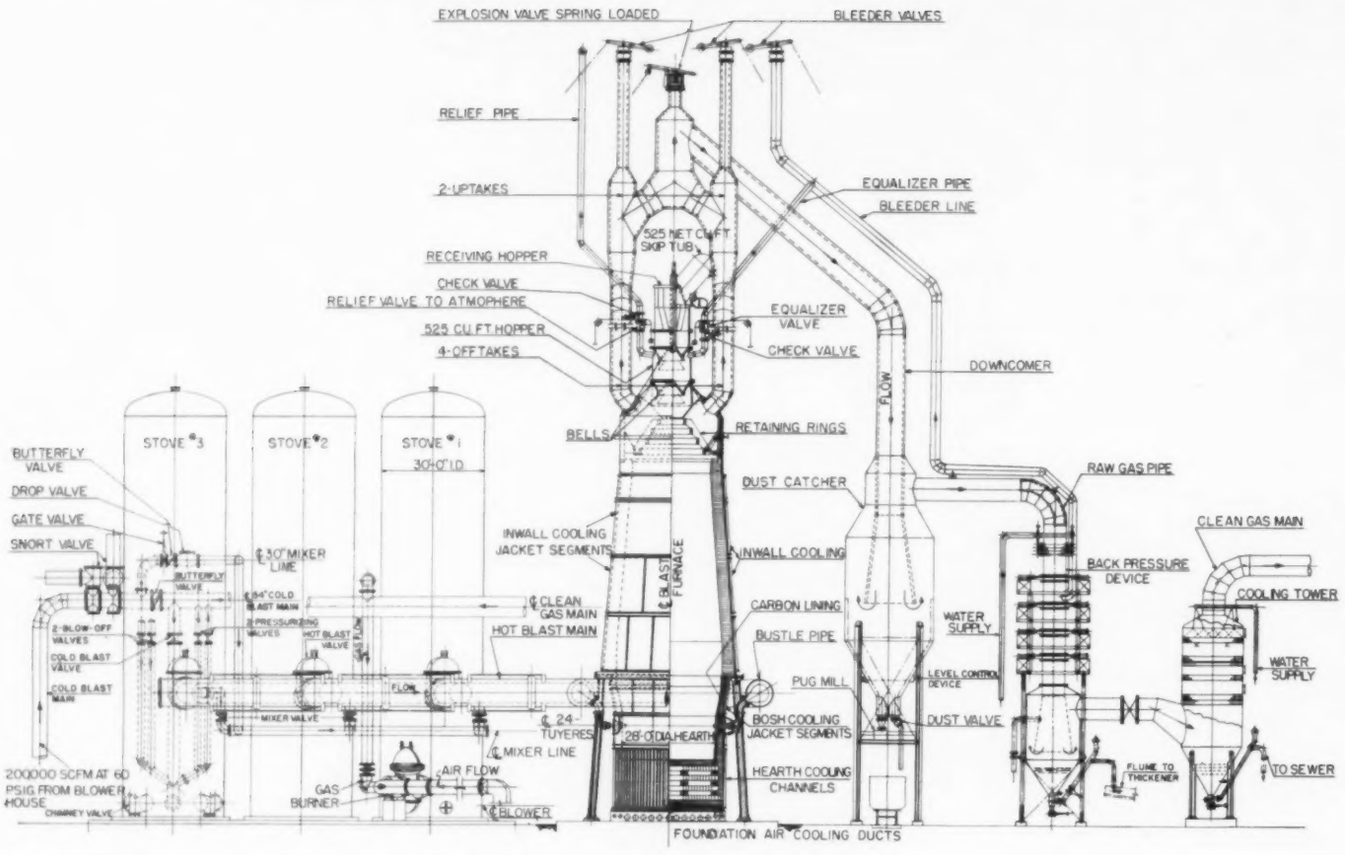


Figure 1 – Many new features are included in proposed new furnace design.

Proposed Furnace Design Should Double Iron Output

DEVELOPMENT of an ultra-high-pressure blast furnace with a top pressure of 40 psi, or nearly four times that at any existing American blast furnace, was announced by Koppers Engineering and Construction Div. It is estimated that the new furnace will produce twice as much pig iron as a furnace of comparable size operated at the normal pressure of about 2 psi. Thus, the output of a blast furnace with a hearth diameter of 28 ft, now averaging perhaps 2000 tons per day at normal pressures, would be in the range of 4000 tons per day at 40-psi top pressure. To achieve this increase in production, an additional capital investment of only 20 to 25 per cent is required. Labor costs required to produce a ton of pig iron with the ultra-high-pressure blast furnace are reduced 30 to 35 per cent.

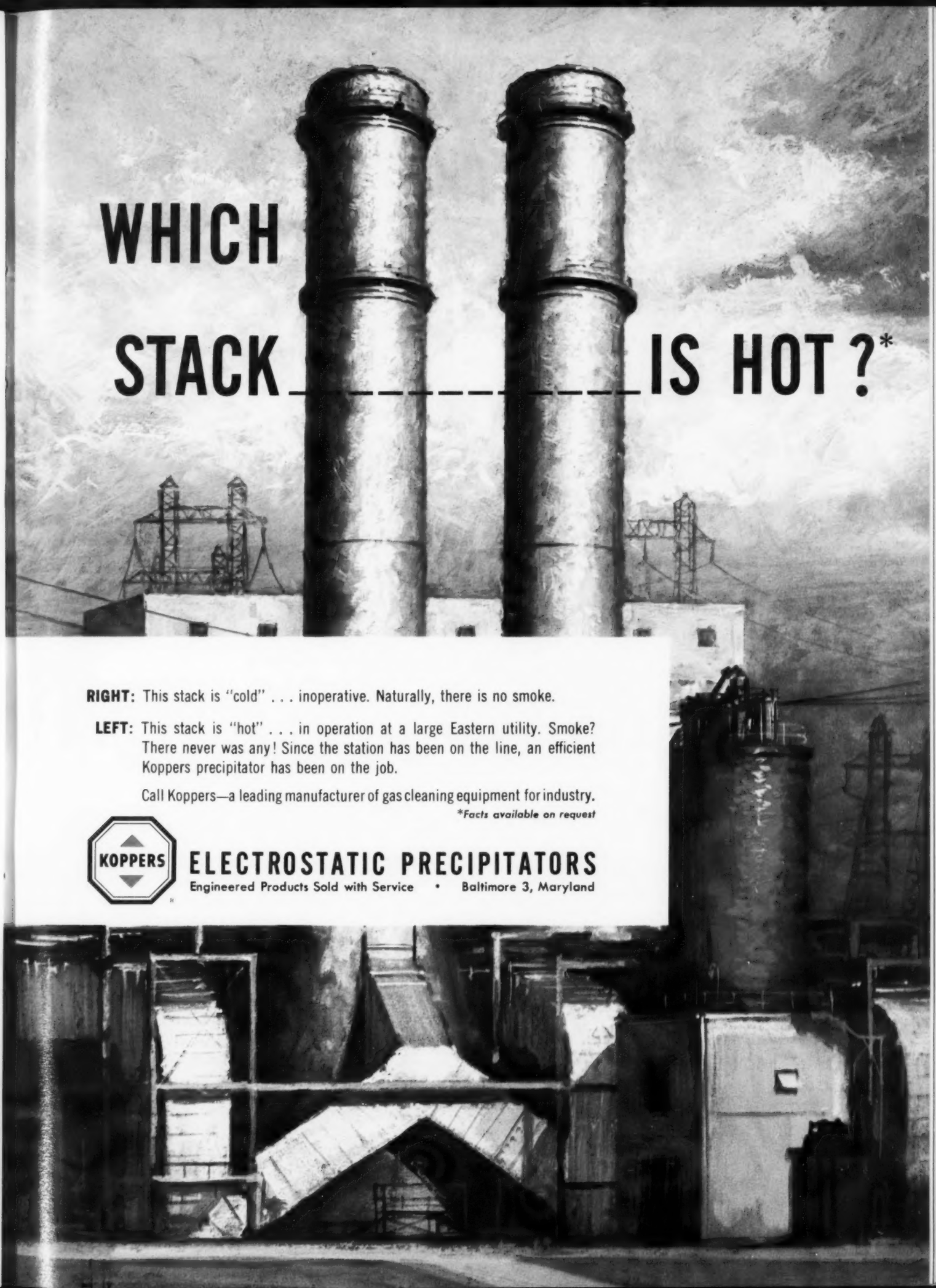
The concept of the ultra-high-pressure blast furnace, as designed by Koppers, requires a completely new installation rather than the addition of high-pressure equipment to an existing furnace, as has been done to date with some twenty American blast furnaces.

The design is based on a 28-ft hearth diameter. Beneficiated raw materials are essential. The shell is continuous structurally from top to bottom with no perforations for cooling elements except for the tuyeres and the slag notches. Shell cooling is entirely external by vertical water panels attached to the shell plates. Instead of cast-iron hearth staves, the hearth jacket is made of 2½-in. rolled plate. The hearth bottom is cooled by forced-air ducts located in the concrete pad under the ceramic hearth bottom blocks. Carbon walls extend to the mantel—another reason for no inside cooling members.

The furnace will have two tap holes, to be used alternately for the ten casts required each day.

A radical departure from the conventional is the filling device at the furnace top. Gone is the big bell and the rotating distributor. Two small bells act only as a gas lock. Equalizer and relief valves serve to secure balanced pressures across the bells. Under the circumstance of the beneficiated charge material, adequate distribution is secured by passing the charge through a throat about seven feet in diameter below the lower bell, onto a pile which is embraced by heavy retaining rings arranged in echelon at an angle greater than the angle of repose of the charge material, so that lumps do not roll down the face of the pile, and so that a pile of controllable shape and height can be maintained.

The historical "round" accumulated on the large bell has disappeared. Each skip load is passed immediately through the two bells



RIGHT: This stack is "cold" . . . inoperative. Naturally, there is no smoke.

LEFT: This stack is "hot" . . . in operation at a large Eastern utility. Smoke? There never was any! Since the station has been on the line, an efficient Koppers precipitator has been on the job.

Call Koppers—a leading manufacturer of gas cleaning equipment for industry.

**Facts available on request*

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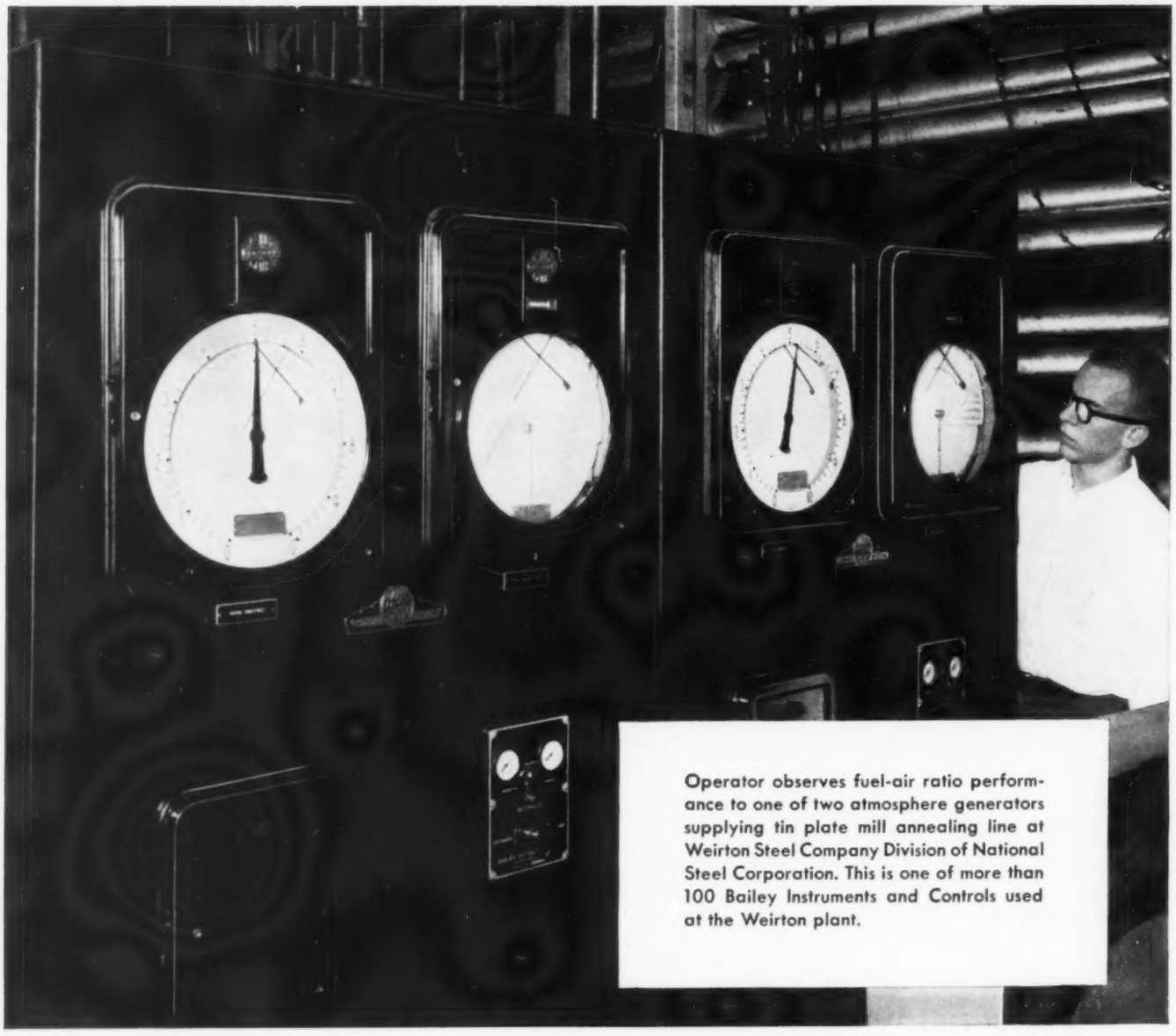

Operator observes fuel-air ratio performance to one of two atmosphere generators supplying tin plate mill annealing line at Weirton Steel Company Division of National Steel Corporation. This is one of more than 100 Bailey Instruments and Controls used at the Weirton plant.

Bailey Atmosphere Generator Control automatically regulates total combustibles for tin plate annealing

Bailey's Atmosphere Generator Control is a completely packaged automatic control system which measures *total combustibles* in annealing.

Manual settings are made only during start-up or shutdown. Fuel-air ratio to generators is adjusted by the control system to maintain constant total combustibles despite variation in fuel quality. Response to atmosphere changes is fast, and total combustibles are accurately measured, since the Bailey Analyzer is not subject to errors due to variability of other atmosphere constituents. The Analyzer is sensitive to changes of less than $\pm 0.02\%$ total combustibles.

The performance of this instrument is assurance of final product quality. See your Bailey Engineer, or write the Iron and Steel Division for more information.

S112-1

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In Canada—Bailey Meter Company Limited, Montreal

and into the furnace. The skip sequence is probably two ores followed by two cokes, two ores, two cokes, etc.

Skip tubs of 525-cu ft capacity, two minutes per skip trip, and 1350 active charging minutes per day will provide a filling rate commensurate with a daily production of 4000 net tons of iron at a coke rate of 1300 lb per ton. There is a leeway of 90 minutes "catch-up" time.

Special measures are taken to face the hoppers, bells and throat with the newest and best in abrasion-resistant coatings. The assembly of these elements would probably be made up as a composite package or cartridge, with suitable provision for expeditous replacement.

It is proposed to reduce furnace height by about 10 ft (giving 72 ft from tuyeres to stock line) to raise top temperature and avoid annoying condensation of water vapor.

The gas-cleaning system serves a dual purpose. It is the back-pressure device responsible for imposing 40 psi upon the furnace top. At the same time it utilizes the entire differential between 40 psi and the desired gas delivery pressure (of say, one psi)—to clean the gas. It consists essentially of a series of automatically adjustable orifice plates in the downtake gas main following the dustcatcher. Water is introduced above the uppermost orifice and passes with the gas successively through each of them. Further cleaning measures would be neither necessary nor effective.

A blast-heating duty of 1800 F line heat for a blast period of 75 minutes or 2000 F for 60 minutes is accomplished in a stove 30 ft in diameter by 140 ft high. The checker weight is 4,200,000 lb and the checker heating surface is 500,000 sq ft. Burners of 50,000-cfm capacity are provided.

An important feature of the stove design is the bottom construction, which in essence makes the stove a pressure vessel.

To meet the blast-temperature specification of 2000 F, the brickwork of the combustion chamber, dome and upper checkers must retain structural integrity at 2300 F. Semi-silica brick are employed in dome and combustion chamber. The upper 8 ft of checkers are of super-duty quality, and the next 10 ft are semi-silica. Stove valves and fittings are designed for a blast pressure of at least 60 psig.

At a production rate of 4000 net tons daily, and at a coke rate of 1300 lb per net ton of iron, the daily coke consumption is 5,200,000 lb. At 53 cu ft of air per lb of coke, and assuming a day of 1420 blast-on minutes, the theoretical blowing rate is 194,000 cfm. A turboblower installation capable of delivering 200,000 standard cfm of air at 60-psi gage pressure will be needed. Manufacturers have expressed no hesitation to undertake its design and construction.

The stockhouse serving a 4000-ton daily pig-iron production will probably call for some revision. The ore bins must become retaining hoppers with six to eight hours capacity and must be filled almost continuously from the principal ore supply, probably by belt conveyor. The same situation applies to the coke bunkers.

It would be feasible to keep this furnace full with the conventional scale car having two 500-cu ft pans. However, a system can be provided wherein each bin is equipped with an apron feeder and a weigh hopper, preset as to weight, and functioning on a preset program. Consignments are delivered by a continuously-running belt to a receiving hopper at the skip pit, which in turn discharges into the skip tub when the latter is in position.

Details of the new furnace are given in an article by Owen R. Rice, who headed a team of engineers working out the new design. ▲

A New Year's Resolution For 1960—

To Reserve These Dates For Attending AISE Meetings

MARCH

		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

WESTERN MEETING
San Francisco, Calif.
March 7, 8, 9

APRIL

					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

SPRING MEETING
Philadelphia, Pa.
April 25, 26, 27

ANNUAL CONVENTION AND EXPOSITION
Cleveland, Ohio
September 27, 28, 29, 30

SEPTEMBER

				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	

High Frequency Equipment Speeds Tube Welding

AN electronic device, which has excited world-wide interest, is revolutionizing the tube and tube welding industries. With this modern electronic machine tool, strips of steel, hot or cold rolled, stainless, copper, brass, aluminum or, in fact, any ferrous or nonferrous metal, and the rarer metals such as zirconium and titanium, can be fed through a standard forming mill to this Thermatool and welded at rates in excess of 250 fpm. Thin wall tubing such as is used for manufacturing tin cans is being produced in excess of a 1000 fpm. Such speeds have never before been possible.

The New Rochelle Tool Corp., one of the pioneers in high frequency electric heating instruments, has utilized the phenomena of high frequency electric resistance to produce the device.

This method represents the most efficient utilization of electrical energy for the production of welded seam tubing that has ever been developed. In order to obtain this result, the electrical energy, with its subsequent conversion to heat, must be concentrated solely on the shallow interfaces of the strip being formed into tubing, and this process achieves this requirement.

An analysis of the basic requirements for tube welding will show them to be extremely elementary. They resolve into the following:

1. The edges of the metal strip to be bonded together must be accurately positioned opposite each other as the strip travels through the mill.

2. The interfaces of the metal going to make up the seam must be heated to permit the metal to fuse when transverse pressure is applied.

3. Sufficient transverse pressure must be applied to form a homogenous bond between the interfaces.

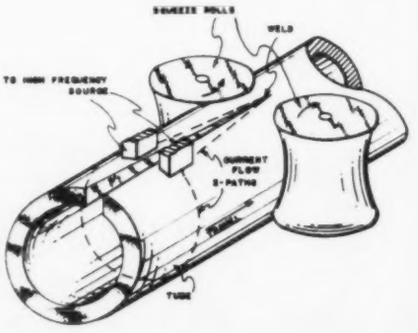
The first and last requirements are mechanical and have already been attained by the fabricators of tube mills. The second feature, involving the heating of the weld section, is the salient point in the Thermatool method. For optimum results, the heat energy should be confined solely to the weld area in order to minimize the deleterious effects on the metallurgical characteristics of the metal adjacent to the weld. Concentration of the heat also reduces the amount of metal deformed, the energy requirements for a given welding speed are reduced proportionately, or to express it differently, the speed of the welding can be increased many times for a given energy consumption, and flux and filler rods are eliminated.

New Rochelle Tool Corp. pioneered the application of the more-or-less overlooked "proximity effect" associated with the path of high frequency current flow to industrial heating processes. The "proximity effect" causes the current to flow in that part of the electrical circuit which is in closest proximity to the return circuit. For example, two bus bars carrying the current of a high frequency circuit would have the current concentrated on the inner faces, regardless of the width of the bus bars.

This principle lent itself admirably to the solution of the heating problem in tube welding, and is the basis of the Thermatool method in which the tubing has two contacts riding on the surface of the strip stock prior to its entrance into the closing rolls on the mill. These contacts are connected to the output terminals of the high frequency transformer, which in turn is energized from the specially designed generator. High frequency current flows out of one of these contacts and back through the other one. The path of current flow between the contacts is dictated by the "proximity effect," and concentrates on the faces of the strip, crossing over at the weld point. As a result, this tube welding method was perfected, and patented.

This welding head is now operating successfully for over fifty companies in this country and in France, Switzerland, Italy, Germany and Japan, with many more on order. Users include the Aluminum Company of Canada, Ltd., in their Kingston, Ont., plant; the Republic Steel Corp.'s Steel and Tube Divi-

Figure 1 — Schematic shows flow of current for welding operation.



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FOR FIGURES IN A HURRY—FIGURE ON A GE COMPUTER

CPA-36A'65-05

Figure 2 — At the top center is the output transformer, and left of the transformer is the power regulator. The two sliding contacts which ride one on each side of the open seam of the formed tube are attached to the fixture directly under the regulator.

Figure 3 — A close-up of the sliding contacts which ride one on each side of the open seam to introduce the 450,000 cps current directly into the metal as the tube passes to the squeeze rolls. Left of the squeeze rolls is the scarfer which removes the upset caused by the welding operation

sion in Cleveland; Reynolds Metal Co.; Aluminum Company of America; Southern Pipe and Casing; James Steel and Tube Co.; and the J. F. D. Manufacturing Co.

Up to recently, before tubing produced by the method was made available in quantity, many users were insistent on seamless or drawn tubing, due to the quality of welded product. Now this high frequency resistance welded product is supplanting extruded tubing due to its quality and economy.

Seamless tubing produced by extrusion or drawn methods must of necessity carry the amortization of a plant costing a million or more dollars plus the heavy expense of operation and maintenance. High original cost and heavy operational expenses are eliminated with the installation of this tool which costs about $50,000, exclusive of the forming mill, and installation expenses.

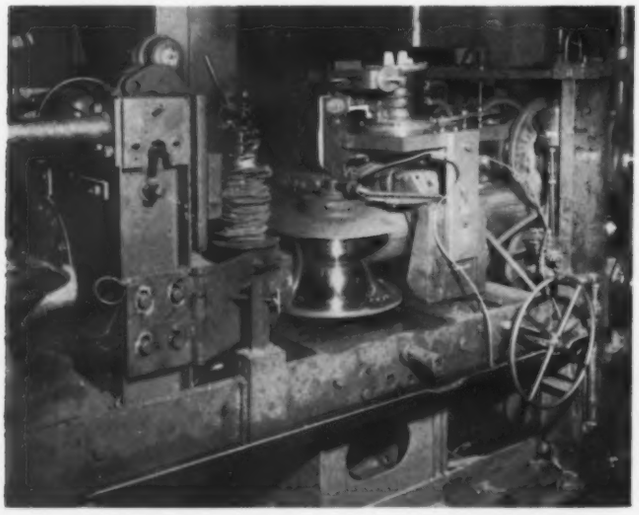
The Republic Steel Corp. recently completed two years' research with Thermatool. The tubing put through rigorous tests had an outside diameter of 1 to 3 in. and wall thickness of 0.050 to 0.100 in. Republic's market covers tubing for use in boilers, conduit, line and pipe casing, and mechanical uses.

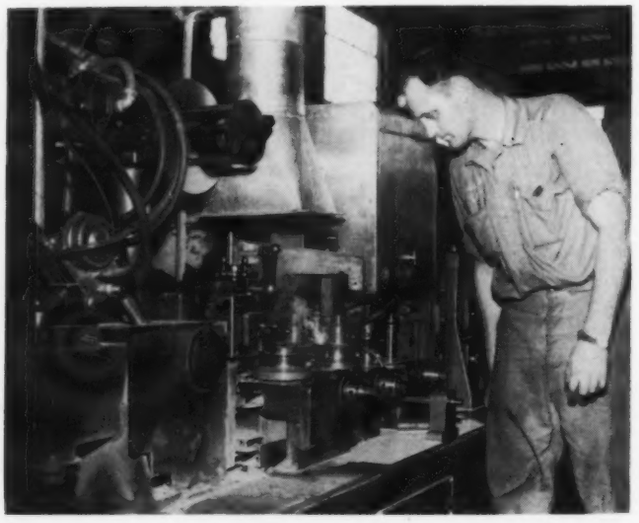
The Aluminum Company of Canada is now producing irrigation and compressed air tubing with diameters up to six inches.

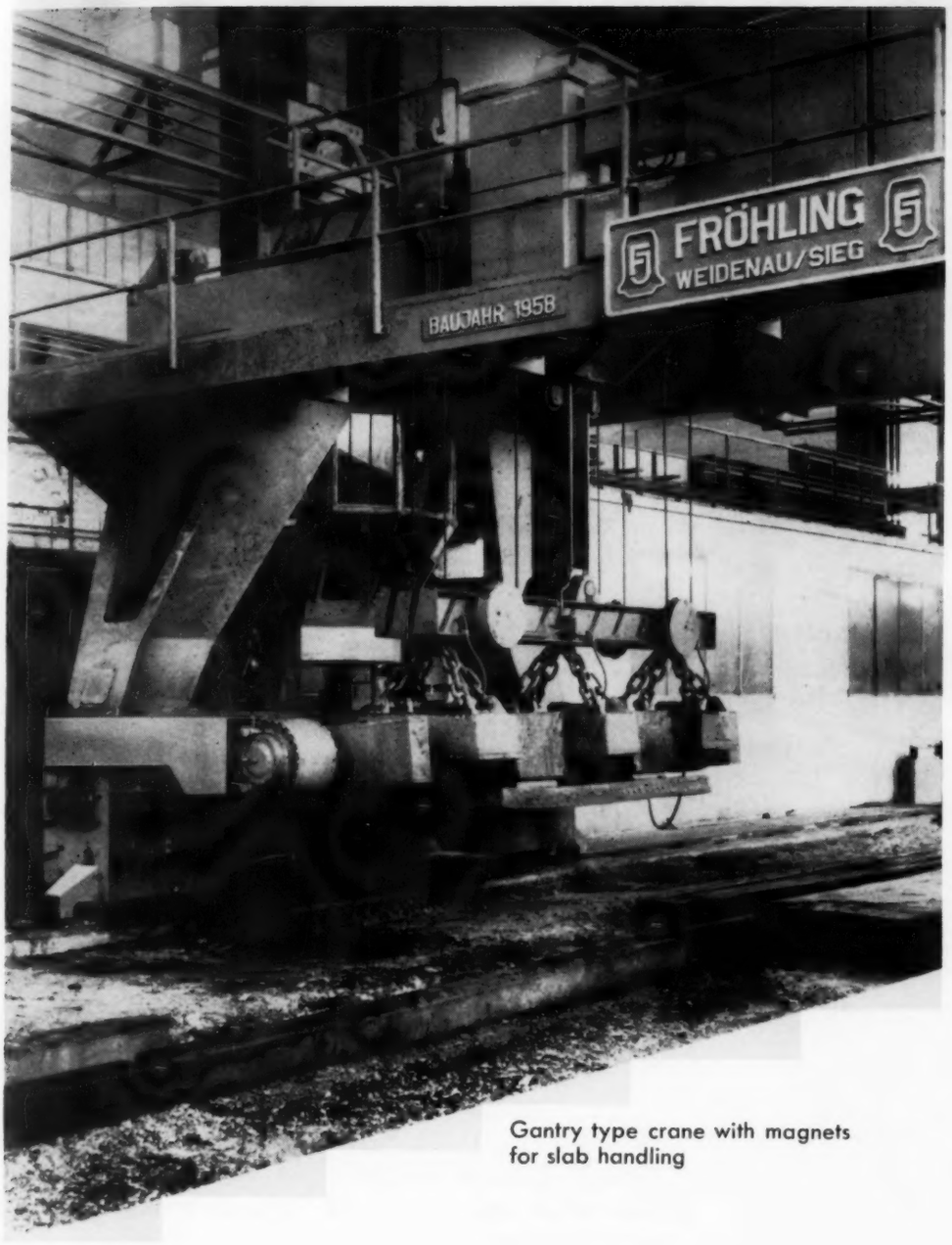
This process has many advantages.

First of all, the electrical energy in this method is concentrated on the interfaces of the stock before it reaches the weld point. Practically no current flows around the tube or in adjacent sections, as in induction welding, and consequently there is no wasted heat. This same restriction of heat also minimizes damage to the metallurgical characteristics of the stock around the weld, and reduces the flash which later must be removed by scarfing.

Figure 4 (left) — Formed open seam pipe is shown entering the weld area. Left of the squeeze rolls is a spindle that collects the waste metal which accumulates from scarfing the upset caused by the welding operation.
Figure 5 (right) — This welder is in operation in the James Steel and Tube Co., Miami, Fla. Two-in. galvanized metal is being formed and welded at speeds in excess of 250 fpm. The bead is scarfed immediately after the weld has been effected and the scarfed area is sprayed to regalvanize this narrow strip on the pipe.







Gantry type crane with magnets
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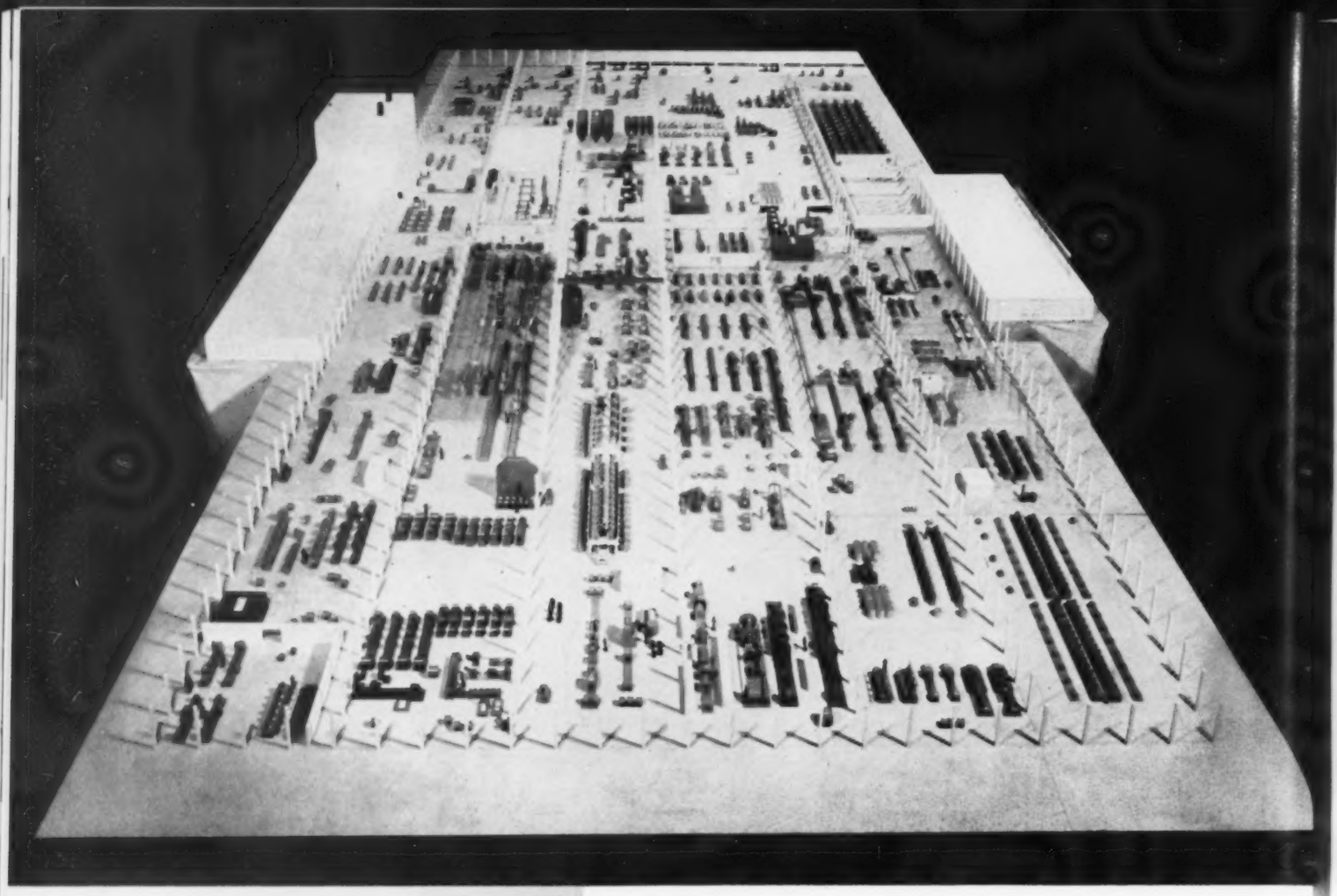
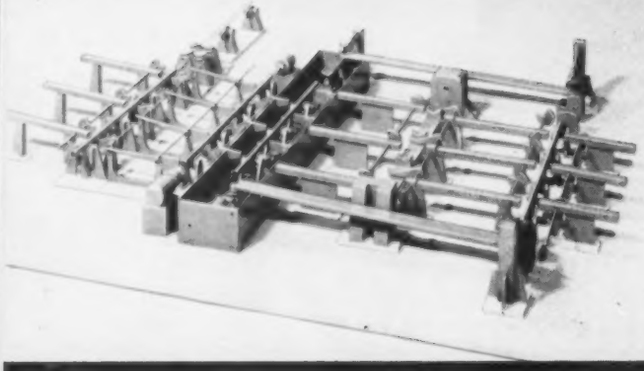
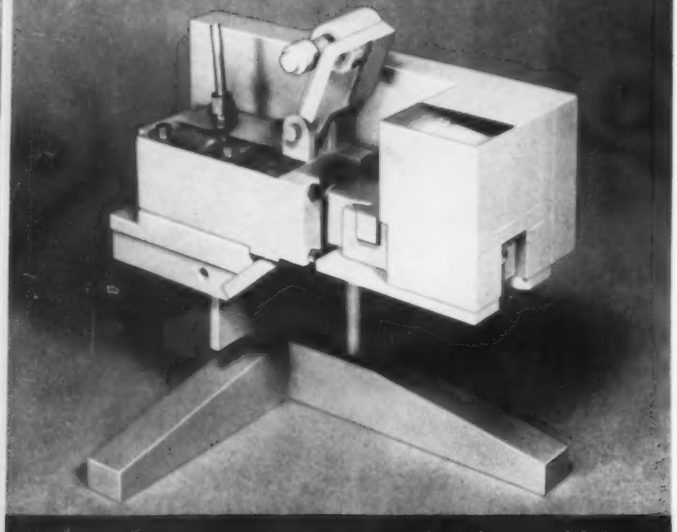
Manufacturer of Rolling Mill Machinery





Pipe Tester—Another Lombard model concept of a machine to test pipe from 5" OD to 13⅜" OD. Pressures up to 24,000 PSI.



Drawbench Carriage detail. An actual working model in dimensions and color to demonstrate the functions in true

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Another outstanding feature of this method is that it is completely independent of the diameter of the tubing being processed. Consequently, for a given wall thickness, the largest diameter tubing can be welded as effectively as the smallest. The rate of speed at which stock can be welded for a given power input depends solely on the wall thickness of the stock; in fact, there is no requirement that the stock be a single strip and the method is finding application in edge forming two strips of metal.

The increased effective resistance of the metal realized by using high frequency current, approaching one-half million cycles per second, permits greatly increased welding speeds on metal already being resistance welded into tubing, and also permits the welding of metal previously considered impossible to resistance weld. In fact, 100 per cent conductivity copper is welded by this method with the same facility as other metals. Installation on tube mills formerly utilizing other welding methods has been able to drastically increase the rate of production.

A salient feature of this method is the case of changeover from one metal to another. At an early demonstration of the process, set up for 2-in. outside diameter by 0.037-in. wall tubing, coils of various aluminum alloys, hot rolled steel, cold rolled steel, stainless steel, brass and copper were run indiscriminately with only slight adjustment of the electrical controls with changes in stock.

This welding method can be adapted to any tube mill. The welding head and associated transformer can be installed in a space from 24 to 36 in. in length between the last set of forming rolls and the closing rolls. Conversion of mills already equipped with welding apparatus is extremely simple. Installation on cold forming mills for butt seam or locked joint tubing presents no major conversion problem. The method can be applied to square, rectangular or other odd shapes.

This method will weld any fusible metallic material. It is also opening new horizons in the tube welding industry since metals previously considered impossible to weld are being made into welded tubing. Changing over from one material to another is a simple matter, with a minimum loss of production.

Welding by this method creates only a small inside bead, much smaller than ever before.

There is practically no inside splatter, usually caused by current fluctuations, hence very little rejection due to an almost consistently clean inside surface. Reprocessing delays are practically nil.

The heat-affected zone is very narrow and this improves bending and flattening characteristics.

Under this method there is seldom excess flash due to the fact that the bead is so small. The inner or outer bead or both can be easily scarfed if desired, without reducing speed of operation.

Fabricators who bend or form tubing do not need to position the welded area. This eliminates the necessity of using extruded tubing where it was formerly mandatory or at least recommended.

A distinct advantage of the process is that it is so designed that if a customer were to buy a 60-kw unit, for example, capable of welding wall thickness of 0.167 in., by the additive of certain equipment the process makes possible the welding of larger gage material and does not obsolete the purchaser's original equipment.

In this process the speed is dependent on the ability of the forming mill to bring the material to the welding head.

Not alone is this high frequency resistance welder more economical; it is a compact device in its application to a forming mill. More important is the fact that the high frequency generator and transformer takes up a floor space of only approximately three by eight feet and seven feet in height permits installation in any plant.

Another phase of high frequency welding by the method is the welding of strip to strip in a flat form. Still another is the welding of differential metals as in the manufacture of saws. The teeth of the saw demand a high-speed steel which in today's market costs approximately $3.80 per pound. It is easy with this process to make perhaps 15 per cent of the saw blade high-speed steel and the balance of low-grade steel costing 35 cents a pound. ▲

You can do **two things** to guard yourself against cancer: Have an annual health checkup. Alert yourself to the seven danger signals that could mean cancer:

1. Unusual bleeding or discharge. **2.** A lump or thickening in the breast or elsewhere. **3.** A sore that does not heal. **4.** Change in bowel or bladder habits. **5.** Hoarseness or cough. **6.** Indigestion or difficulty in swallowing. **7.** Change in a wart or mole.

If your signal lasts longer than two weeks, go to your physician. Give him the chance to give you the chance of a lifetime.

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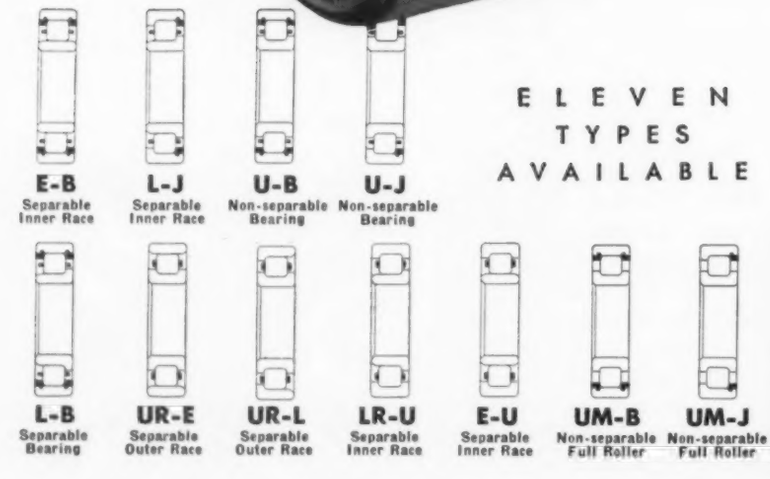

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News and Notes on...

Good Packing Practice

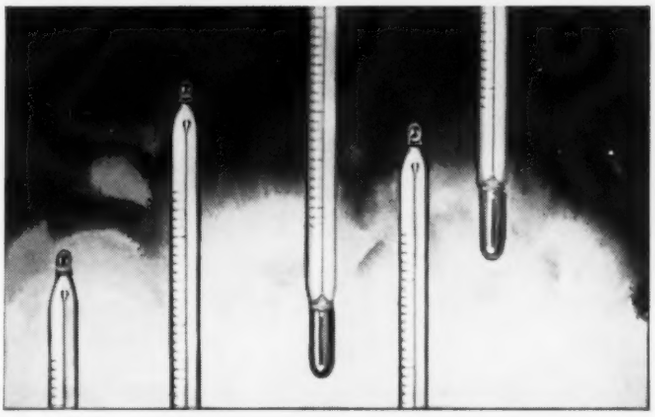
JOHNS-MANVILLE JM PRODUCTS

Maintenance and Design Hints from Johns-Manville Packings and Textiles Dept.

Subject of the month: High Operating Temperatures

Question:

What sealing materials are currently available that will match conditions brought about by higher and higher operating temperatures?



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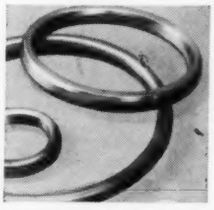
Wherever your operation calls for a utility gasketing material that withstands both heat and flame, specify J-M Asbestos Rope, Style 4200. Made of 99% pure asbestos, this material can take temperatures far in excess of other grades of rope. You'll find it a handy, reliable gasket for sealing joints between furnace doors and brickwork, boiler expansion joints, blast furnace connections, ingot moulds, and countless other uses. Ask for information about J-M Style 4200 Asbestos Rope.

Condition 3

FOR FLANGES WORKING AT TEMPERATURES TO 1600F AND HIGHER



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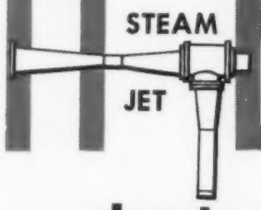
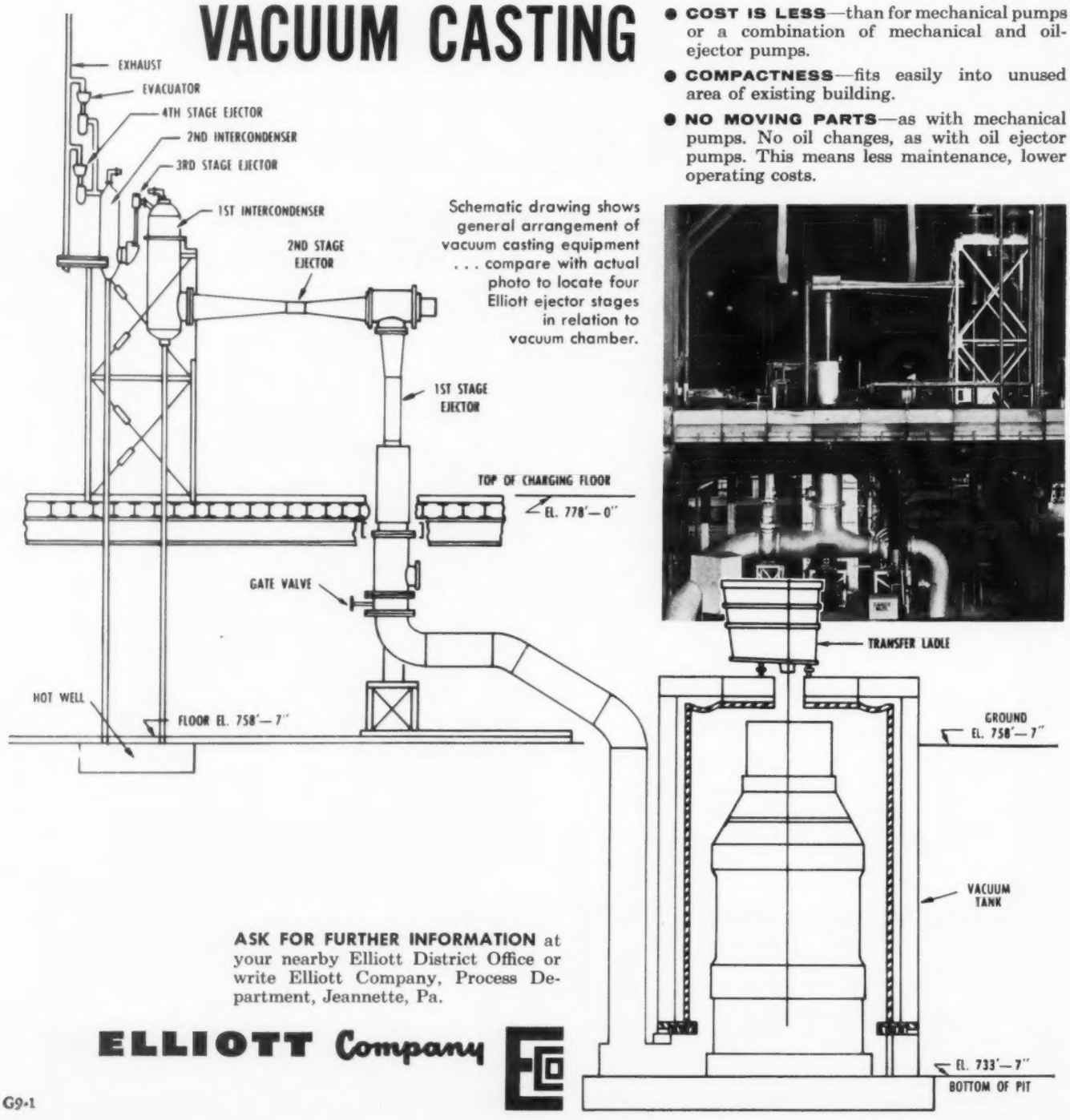
ELLIOTT EJECTORS



selected by United States Steel for VACUUM CASTING

This simplified method of removing unwanted gases assures stronger, more uniform forgings and reduced flaking and embrittlement. One of the several production-size degassing operations served by Elliott steam-jet ejectors is the United States Steel Corporation installation seen here. A 36-in. four-stage ejector system, it was selected because:

- **COST IS LESS**—than for mechanical pumps or a combination of mechanical and oil-ejector pumps.
- **COMPACTNESS**—fits easily into unused area of existing building.
- **NO MOVING PARTS**—as with mechanical pumps. No oil changes, as with oil ejector pumps. This means less maintenance, lower operating costs.



Schematic drawing shows general arrangement of vacuum casting equipment . . . compare with actual photo to locate four Elliott ejector stages in relation to vacuum chamber.

ASK FOR FURTHER INFORMATION at your nearby Elliott District Office or write Elliott Company, Process Department, Jeannette, Pa.

ELLIOTT Company

G9-1

Date-line Diary...

October 1

Δ The commerce Dept. reported that August, 1959, exports totaled $1,299,600,000, imports amounted to $1,189,800,000. Both incoming and outgoing goods fell 5 per cent in volume below July, 1959.

Δ The Aluminum Assn. reports that net shipments of aluminum sheet and plate for August, 1959, totaled 97,350,000 lb, compared with 173,129,000 lb in July, 1959. Shipments of aluminum foil in August, 1959, totaled 19,263,786 lb compared with 24,807,173 lb in July, 1959.

October 2

Δ The American Iron Ore Assn. reports that shipment of iron ore down Lake Superior in September, 1959, totaled 758,314 gross tons compared with 8,705,886 tons in September, 1958.

Δ Bureau of the Census, U. S. Dept. of Commerce, reports that net shipments of aluminum mill products in July, 1959, amounted to 373,000,000 lb, compared with 341,000,000 lb in June, 1959; net shipments of aluminum ingot, both primary and secondary, in July, 1959, totaled 136,000,000 lb compared with 182,000,000 lb in June, 1959; net shipments of magnesium mill products during July, 1959, amounted to 1,698,000 lb compared with 1,946,000 lb in June, 1959.

October 4

Δ The USW 33-man executive committee rejected the first cash offer made by the Big 12 steel producers since the strike began 83 days ago. The proposal was tied to industry's demands for greater freedom to change working rules.

October 5

Δ Price of No. 1 grade steel scrap rose $3.00 a ton at Pittsburgh mill, to $41 a ton.

Δ The AISI reports that the operating rate of the steel industry for the week of October 5, is scheduled at 365,000 tons (12.9 per cent of capacity). This compares with 362,000 tons one week ago (12.8 per cent capacity), and 1,933,000 tons one year ago. Index of production for the week is 22.7.

Δ The Bureau of Mines reported that production of Pennsylvania anthracite for September, 1959, was 1,703,000 net tons compared with 1,515,000 net tons in August, 1959, and 2,050,000 tons in September, 1958.

October 6

Δ Machine tool orders in August, 1959, amounted to $52,400,000 compared with $63,400,000 in July, 1959, and $28,300,000 in August, 1958.

Δ Major railroads' net income in August, 1959, fell to $26,000,000, compared with $32,000,000 in July, 1959.

October 7

Δ Retail auto sales in September, 1959, fell to 348,400 U. S.-made cars, 30 per cent over September, 1958.

Δ Phoenix Steel Corp. has been offered a $44,000,000 credit by a British manufacturing group to finance proposed construction of a steel plant in Burlington, N. J., with an annual capacity of 800,000 tons.

October 9

Δ Alan Wood Steel Co. shareholders approved a company proposal to eliminate restrictions on the amount of long-term debt the company can incur.

Δ Dominion Steel & Coal Corp., Ltd. reported for the fiscal year ended July 31, 1959, net income of $3,128,466 equal to $1.06 a share.

Δ U. S. Dept. of Commerce, Bureau of the Census reported that shipments of iron and steel castings in July, 1959, amounted to 1,119,460 short tons compared with 1,481,137 tons in June, 1959, and 902,227 tons in July, 1958.

October 12

Δ The AISI reports that the operating rate of the steel industry for the week of October 12, is scheduled at 365,000 tons (12.9 per cent of capacity). This compares with 362,000 tons one week ago (12.8 per cent capacity) and 2,003,000 tons one year ago. Index of production for the week is 22.7.

October 13

Δ Auto dealers inventory of cars as of October 1, 1959, totaled 610,000 cars, 50 per cent above the inventory October 1, 1958.

Δ General Electric Co. reported for the third quarter of 1959, ended September 30, sales totaling $1,076,850,000, earnings $72,273,000, compared with the same period of 1958, sales $1,003,621,000, earnings $58,589,000. For the first three quarters of 1959, sales totaled $3,142,297,000, net income $189,512,000 equal to $2.16 a share; for the same period in 1958, sales totaled $2,982,615,000, net income $161,970,000 or $1.85 a share.

October 14

Δ The Labor Dept. reported that unemployment in the month ended September 15, totaled 3,230,000, 196,000 less than the month earlier; total employment was 66,300,000, a decrease of 894,000.

Δ Johns Manville Corp. estimated that housing starts in 1959, will reach 1,380,000 starts, compared with 1,209,400 in 1958.

Δ The Bureau of Census, U. S. Dept. of Commerce, reports that production of titanium ingots totaled 492,348 lb in August, 1959, compared with 641,460 lb in July.

Δ The Board of Directors, Copperweld Steel Co., took action to redeem all the company's preferred stock as of December 14, 1959.

October 15

Δ Government figures showed that private housing starts in September, 1959, fell to a seasonally adjusted annual rate of 1,325,000, compared with an annual pace of 1,340,000 in August, 1959, and 1,255,000 in September, 1958.

October 16

Δ The AAR estimated that major railroads have lost 2,000,000 cars of freight business as a result of the steel strike since mid-July. Freight loadings in the week ended October 10, declined to 558,780 cars, 2.4 per cent below the preceding week, and 18.6 per cent below the like 1958 period.

October 17

Δ The Aluminum Assn. reported that primary aluminum production in the United States during September, 1959, was 168,205 short tons compared with 172,817 short tons in August, 1959, and 125,939 tons in September, 1958.

October 19

Δ The AISI reports that the operating rate of the steel industry for the week of October 19, is scheduled at 371,000 tons (13.1 per cent of capacity). This compares with 368,000 tons one week ago (13.0 per cent capacity), and 2,026,000 tons one year ago. Index of production for the week is 23.1.

Δ The Commerce Dept. estimated the value of construction activities at $5,100,000,000 in September, 1959, compared with $5,200,000,000 in August, 1959, and $4,700,000,000 in September, 1958.

October 20

Δ The ARCI reported that deliveries of new freight cars in September, 1959, totaled 2481 compared with 4890 in August, 1959, and 2198 in September, 1958. Sales in September totaled 945 compared with 1753 in August and 1585 in September, 1958. Backlog of cars on order as of October 1, 1959, was 35,626 compared with 37,172 on September 1, 1959, and 24,982 on October 1, 1958.

Δ President Eisenhower ordered the Attorney General to seek an injunction under the Taft-Hartley law to halt the 98-day-old steel strike.

Δ The Commerce Dept. reported that personal income at mid-July, 1959, declined to a seasonally adjusted annual rate of $383,400,000,000 (corrected) compared with $383,800,000,000 at mid-June, the rate declined to $380,000,000,000 early in August, and to $379,400,000,000 in September.

Δ Bureau of the Census, U. S. Dept. of Commerce, reported that shipments of copper-base mill and foundry products in the second quarter of 1959 totaled 1,265,000,000 lb, compared with 1,232,000,000 lb in the first quarter of 1959, and 940,000,000 lb in the second quarter of 1958.

October 22

Δ Colorado Fuel and Iron Corp. directors have called a special meeting of stockholders for December 16, to vote on an increase in the authorized common stock to 10,000,000 shares from 5,000,000 and to change it to $5.00 par value from no par value.

Δ Woodward Iron Co. has offered to buy the assets of Western Pipe and Foundry Co. The transaction would involve $2,500,000, part cash, part deferred consideration to be paid out of Western Pipe earnings. Western Pipe stockholders will vote on the proposal October 23, at a special meeting.

Δ The Government won a Taft-Hartley injunction in the Pittsburgh District Court to halt the 99-day-old steel strike for 80 days. But the order was stayed pending an appeal by the USW.

Δ Zinc price increased 1¢ to 13¢ a lb by a large custom smelter in East St. Louis. This was quickly followed by St. Joseph Lead Co.

Δ The Bureau of the Census reports that shipments of commercial steel forgings in August, 1959, totaled 95,740 short tons compared with 102,908 short tons in July, 1959, and 79,873 short tons in August, 1958.

October 23

Δ Bureau of the Census reports that net shipments of aluminum pig and ingot totaled 66,417,000 lb in August, 1959, compared with 136,356,000 lb in July, 1959, and 87,609,000 lb in August, 1958; receipts in August, 1959, totaled 127,050,000 lb. Net shipments of aluminum mill products in August, 1959, totaled 247,833,000 lb, compared with 373,060,000 lb in July, 1959, and 213,441,000 lb in August, 1958; receipts in August, 1959, totaled 20,428,000 lb.

Δ Bureau of the Census reports that shipments of nonferrous castings in August, 1959, totaled 175,780,000 lb compared with 176,863,000 lb in July, 1959.

Δ Can Mfrs. Institute, Inc., report that steel consumed for cans in August, 1959, totaled 614,764 tons an increase of 3.6 per cent over August, 1958.

October 26

Δ Steel negotiations were resumed under court order. They will set up company-by-company talks between 13 steel producers and local union representatives in Pittsburgh. Similar parleys will be held throughout the nation affecting the 83 other strike bound steel companies.

Δ The AISC reported that bookings of fabricated steel in September, 1959, totaled 284,114 tons compared with 196,985 tons in August, 1959, and 255,584 tons in September, 1958. Shipments in September, 1959, totaled 182,596 tons compared with 220,420 tons in August, 1959, and 313,701 tons in September, 1958. Backlog of future work as of September 30, totaled 1,870,763 tons.

Δ The AISI reports that the operating rate of the steel industry for the week of October 26, is scheduled at 368,000 tons (13.0 per cent of capacity). This compares with 371,000 tons one week ago (13.1 per cent capacity), and 2,024,000 tons one year ago. Index of production for the week is 22.9.

Δ In a separate settlement Kaiser Steel Corp. and USW reached an agreement ending the strike there. Terms of the agreement were apparently a 2-year contract, providing a 17-cent increase in wages and fringes.

October 27

Δ The Commerce Dept. reported that commercial shipments overseas in September, 1959, totaled over $1,400,000,000, 10 per cent over August, 1959, and 15 per cent over September, 1958.

Δ President's Council of Economic Advisers reported that national production of goods and services in the third quarter of 1959 fell to $481,000,000,000, down $3,500,000,000 from the second quarter pace.

October 28

Δ The three-judge U. S. Circuit Court of Appeals in Philadelphia upheld the Taft-Hartley injunction sending the steelworkers back to the mills, but allowed the strike to continue for at least six more days to give the union time to appeal to the Supreme Court.

Δ Detroit Steel Corp. signed a separate contract with the USW reportedly on the same basis as the Kaiser Steel Corp. contract.

Δ National Machine Tool Builders Assn. report new orders for September, 1959, totaling $59,600,000 compared with $52,200,000 in August, 1959; shipments in September, 1959, totaled $45,800,000 compared with $40,300,000 in August, 1959; estimated backlog (in months) 5.0 on September 30, 1959.

Δ The Bureau of Statistics reports (Canada) steel production of ingots at 484,671 tons in September, 1959, compared with 241,855 in September, 1958; pig iron production in September, 1959, totaled 361,994 tons compared with 186,326 tons in September, 1958.

Δ Westinghouse Electric Corp. report 1959 third quarter sales of $494,189,000, net profit of $22,075,000 or $1.25 per share compared with sales of $460,538,000, net profit of $19,038,000 or $1.09 per share for the third quarter of 1958. For the first nine months of 1959, sales totaled $1,408,000,000, net income $56,225,000 or $3.17 per share compared with the nine-month period of 1958, sales $1,384,000,000, net income $49,011,000 or $2.79 per share. The board of directors of the corporation have recommended that the stockholders approve a two-for-one split of the common shares at a special meeting to be held January 4, 1960, in Pittsburgh.

Steel Companies Quarterly Financial Reports—July 1, 1959, to September 30, 1959

	Period	1959 Gross income	1959 Net profits	1959 Earnings per share	1958 Gross income	1958 Net profits	1958 Earnings per share
Acme Steel Co.	3rd quar.	...	$ (1,556,335)	...	$ 32,998,423	$ 1,631,088	$0.59
	9 mo.	...	2,961,283	$0.97	90,898,541	3,208,284	1.16
Alan Wood Steel Co.	3rd quar.	$ 19,320,000	985,000	1.33	12,555,240	538,650	0.69
	9 mo.	58,648,000	3,082,000	4.17	37,765,061	878,000	1.00
Allegheny Ludlum Steel Corp.	3rd quar.	18,248,896	(3,913,320)	(1.01)	45,115,055	1,155,429	0.30
	9 mo.	181,246,918	8,455,688	2.19	144,350,345	2,527,396	0.66
Armco Steels, Ltd.	3rd quar.	194,071,181	8,852,896	0.60	214,390,243	12,876,598	0.87
	9 mo.	795,137,615	59,445,964	4.02	629,879,986	33,833,342	2.29
Atlantic Steel Co.	9 mo.	...	907,017	2.20	...	222,257	0.47
Bethlehem Steel Co.	3rd quar.	198,676,783	(38,926,913)	...	472,391,333	26,240,677	0.55
	9 mo.	1,646,822,901	84,231,916	1.75	1,476,000,044	80,063,586	1.68
Carpenter Steel Co.	1st quar.	19,195,013	2,151,368	2.32	11,992,698	66,120	0.70
Colorado Fuel and Iron Corp.	3rd quar.	...	...	...	...	1,607,143	0.43
	9 mo.	...	...	...	...	1,280,435	0.26
Continental Steel Corp.	3rd quar.	...	1,057,379	2.05	12,304,306	1,021,236	1.98
	9 mo.	...	3,845,836	7.45	35,732,931	2,690,990	5.21
Copperweld Steel Co.	3rd quar.	26,528,845	684,755	0.59	22,931,222	898,028	0.80
	9 mo.	101,083,020	4,182,573	3.67	63,365,189	690,890	0.54
Crucible Steel Co. of America	3rd quar.	...	(2,034,000)*	(0.56)*	43,355,875	854,374	0.22
	...	...	6,587,000*	1.66*	129,221,644	1,253,701	0.33
Detroit Steel Corp.	3rd quar.	25,235,972	2,120,414	0.69	15,350,741	306,533	0.08
	9 mo.	81,987,436	7,712,648	2.52	42,194,346	4,694	(0.06)
Eastern Stainless Steel Corp.	3rd quar.	14,601,574	713,130	0.50	13,245,074	753,449	0.53
	9 mo.	51,080,770	2,342,486	1.63	34,824,769	1,686,676	1.18
Firth Sterling, Inc.	3rd quar.	...	...	...	3,279,900	(218,100)	(0.16)
	9 mo.	...	...	...	10,204,000	(771,200)	(0.56)
Granite City Steel Corp.	3rd quar.	34,431,230	3,248,008	1.51	31,292,514	2,323,977	1.08
	9 mo.	119,604,628	11,552,334	5.39	88,738,226	6,218,560	2.89
Inland Steel Co.	3rd quar.	105,967,304	(7,449,109)	(0.43)	167,535,650	12,118,009	0.70
	9 mo.	575,172,705	34,723,272	1.99	477,717,219	32,197,740	1.86
Interlake Iron Corp.	3rd quar.	...	587,955	0.26	20,967,931	339,271	0.15
	9 mo.	89,526,181	6,176,145	2.75	58,510,458	1,584,461	0.71
Jones & Laughlin Steel Corp.	3rd quar.	66,674,000	(16,465,000)	(2.15)	161,828,000	6,698,000	0.81
	9 mo.	619,442,000	25,741,000	3.15	462,627,000	12,389,000	1.45
Kaiser Steel Corp.	3rd quar.	...	...	...	41,182,441	(1,922,742)	(0.85)
	9 mo.	...	...	...	134,495,495	2,047,395	...
Keystone Steel & Wire Co.	3rd quar.	...	1,813,565	0.97	...	1,523,270	0.81
Lone Star Steel Co.	9 mo.	80,551,650	10,022,477	2.81	34,965,708	645,635	0.18
Lukens Steel Co.	36 wks.	68,703,921	3,097,940	3.24	73,073,371	3,537,391	3.71
McLouth Steel Corp.	3rd quar.	...	(3,183,566)	...	47,900,000	2,766,781	1.60
	9 mo.	...	7,473,567	...	112,400,000	5,083,618	2.60
National Steel Corp.	3rd quar.	128,445,011	2,821,600	0.36	150,063,398	10,892,433	1.47
	9 mo.	567,175,136	42,282,708	5.62	381,351,592	21,221,621	2.86
Phoenix Steel Corp.	3rd quar.	14,858,000	489,000	0.47	6,793,471	(206,903)	(0.20)
	9 mo.	21,944,000	978,500	0.94	21,943,826	(1,267,000)	...
Pittsburgh Coke & Chemical Co.	3rd quar.	12,719,000	291,000	0.16	11,775,000	272,000	0.14
	9 mo.	50,580,000	2,012,000	1.46	33,316,000	715,000	0.34
Pittsburgh Steel Co.	3rd quar.	6,507,028	(4,105,001)	...	30,576,338	(291,638)	...
	9 mo.	120,241,405	(63,483)	...	93,603,501	(1,824,297)	...
Republic Steel Corp.	3rd quar.	63,995,186	(24,861,406)	...	221,394,657	15,194,641	0.97
	9 mo.	848,650,393	42,228,311	2.69	638,623,447	39,089,243	2.50
Sharon Steel Corp.	3rd quar.	9,599,472	(1,560,080)	...	24,314,361	66,484	0.06
	9 mo.	93,174,182	1,510,825	1.37	69,036,675	(952,450)	(0.87)
United States Steel Corp.	3rd quar.	368,377,169	(31,135,136)	...	872,167,927	28,239,657	1.27
	9 mo.	2,894,706,849	223,813,360	3.80	2,535,329,741	216,573,654	3.56
Universal Cyclops Steel Corp.	3rd quar.	22,047,203	361,553	0.22	22,069,473	1,087,108	0.65
	9 mo.	89,281,256	5,676,733	3.38	57,945,537	1,910,079	1.14
Vanadium Alloys Steel	3rd quar.	6,937,492	522,876	0.83	4,381,386	181,303	0.29
Washington Steel Corp.	3rd quar.	...	...	...	...	553,963	0.90
	Year	...	...	...	...	800,631	1.26
Wheeling Steel Corp.	3rd quar.	17,334,000	(4,263,000)	...	56,003,000	1,842,000	0.72
	9 mo.	173,653,000	6,748,000	2.78	159,680,000	4,811,000	1.80
Woodward Iron Co.	3rd quar.	...	1,424,689	0.55	...	974,929	0.46
	9 mo.	...	3,784,542	1.67	...	2,714,831	1.28
Youngstown Sheet and Tube Co.	3rd quar.	58,618,449	(7,149,660)	(2.06)	120,027,555	3,641,906	1.06
	9 mo.	487,381,809	21,555,145	6.20	359,550,052	11,545,647	3.32

Losses denoted by parentheses. * Denotes estimated figures

△ The Bureau of Mines reports that consumption of ferrous scrap in the United States in 1958, totaled 56,359,935 short tons compared with 73,548,823 short tons in 1957; pig iron used in 1958 was 57,262,336 short tons compared with 76,353,126 in 1957.

△ The Granite City Steel Co., and USW agreed on economic issues to be included in a new 2-year contract that will run until July 1, 1961. The company has been operating under an extension of its old contract since the steel strike began in mid-July.

October 30

△ The Aluminum Assn. reported that shipments of aluminum sheet and plate in September, 1959, totaled 105,811,000 lb, compared with 97,350,000 lb in August, 1959. Shipments of aluminum foil in September, 1959, totaled 20,344,492 lb compared with 19,263,786 lb in August, 1959.

△ The Bureau of Census, U. S. Dept. of Commerce, reports that shipments of iron and steel castings for August, 1959, totaled 906,640 short tons compared with 1,119,460 tons in July, 1959, and 932,611 tons in August, 1958.

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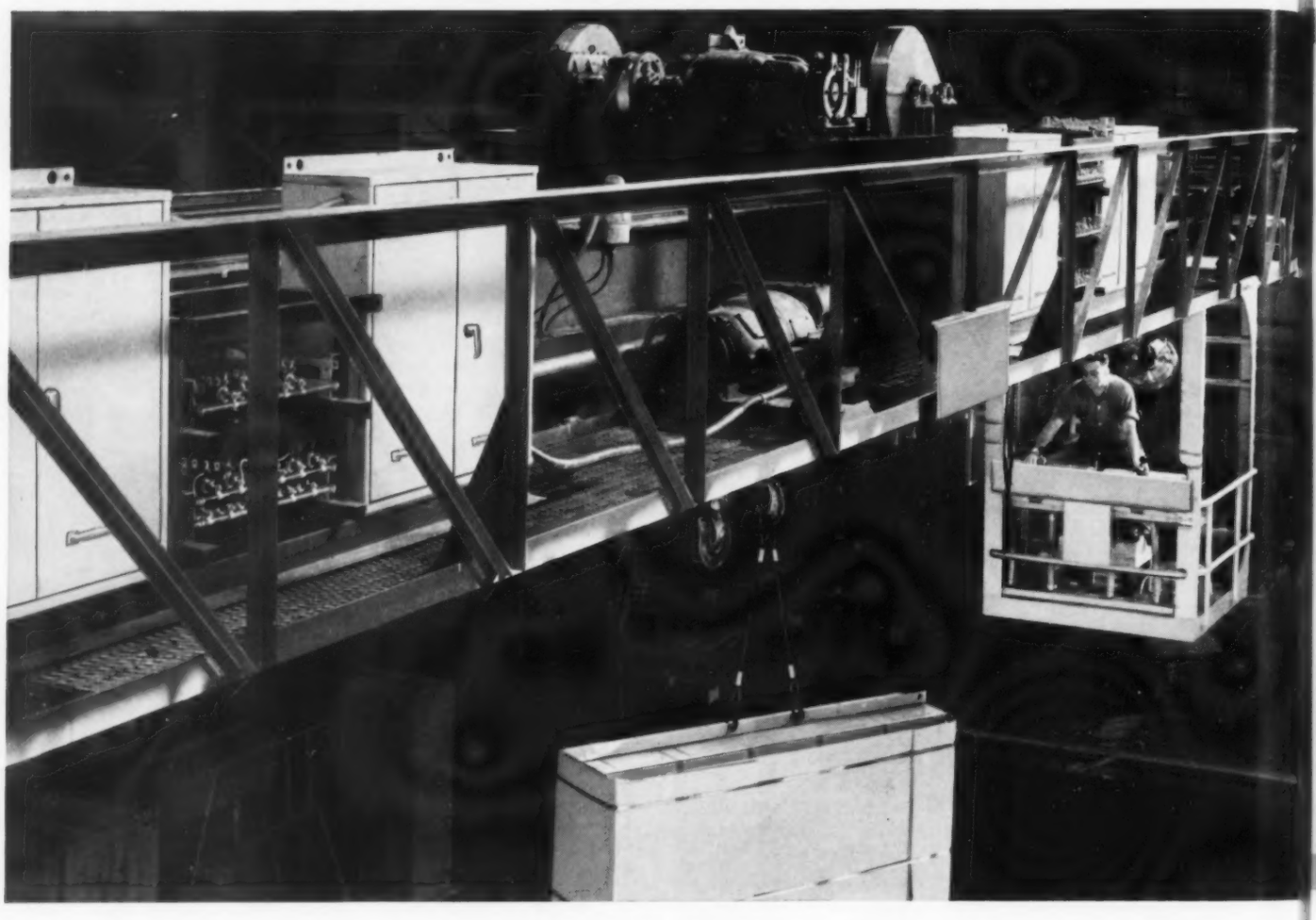

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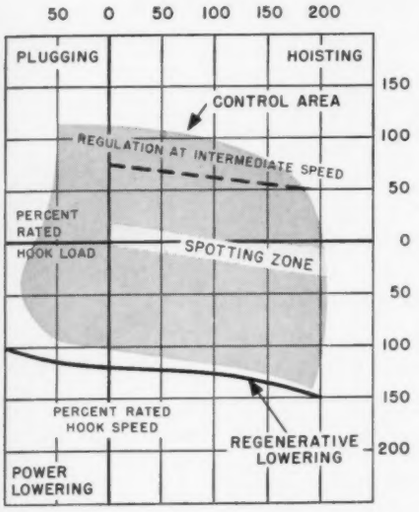

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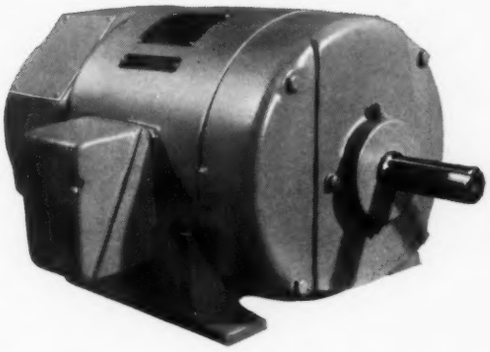
Balanced motor currents	✓	✓		
"Spotting zone" control for accurate positioning	✓			
Control from one master switch	✓	✓		✓
Completely stepless control	✓			
Total number of power contactors	1	2	3	8
Total number of relays (excluding overload relays)	2	4	6	13
Eliminates secondary accelerating contactors and relays	✓	✓		
Eliminates need for both electrical and mechanical load brakes	✓		✓	✓
Trolley collectors required	9	10	10	10
Flat speed-torque characteristic on *all* master switch positions	✓			



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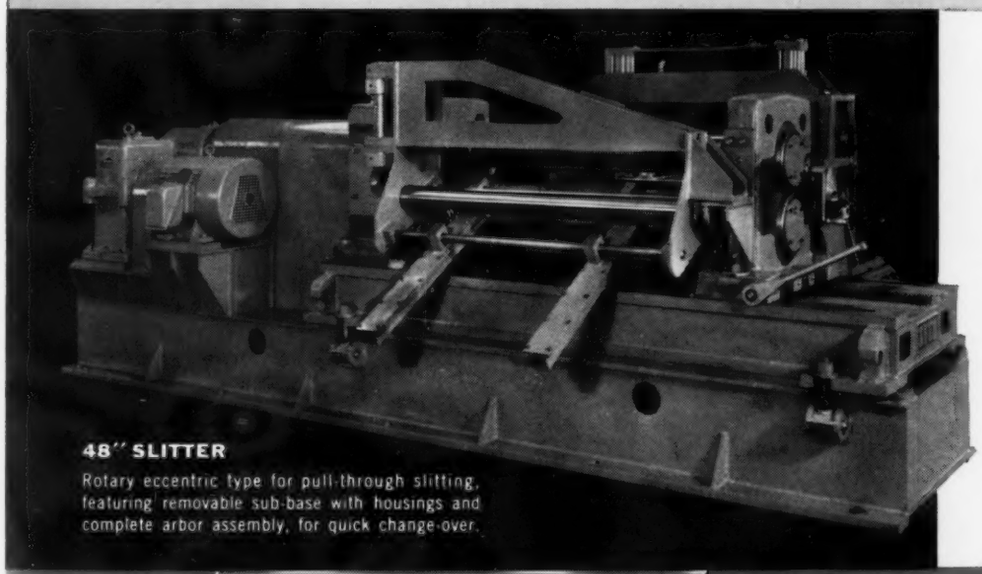

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P. O. BOX 737, WARRENSVILLE STATION
CLEVELAND 22, OHIO

Ohio Rolls

shaping metal for all Industry

The Ohio Steel Foundry Co.

LIMA, OHIO ... *Virtually at the center of the steel industry*

PLANTS AT LIMA AND SPRINGFIELD, OHIO

OHIO IRON AND STEEL ROLLS

Carbon Steel Rolls	Flintuff Rolls	Denso Iron Rolls
Ohioloy Rolls	Double-Pour Rolls	Nickel Grain Rolls
Ohioloy "K" Rolls	Chilled Iron Rolls	Special Iron Rolls
Nioloy Rolls	Forged Steel Rolls	

Industry News...

ARMCO ANNOUNCES EXPANSION PROGRAM FOR ITS MIDDLETOWN, OHIO, RESEARCH CENTER

△Armco Steel Corp. has announced plans to double the size of its research center at Middletown, Ohio, and push forward with the most extensive product and process research program in its history.

Total cost of the building extension and new research equipment will be more than $3,500,000.

The expansion project provides for a 69,000 sq ft addition to the Middletown laboratories together with additional laboratory equipment. Upon completion of the addition, the research center will contain about 113,000 sq ft of floor space.

T. F. Olt, vice president—research, explained that the addition will provide space for the expansion of present laboratories and for the installation of several additional laboratories to explore new fields. One will be a laboratory for nuclear studies where radioactive isotopes will be used extensively. New facilities for testing full scale structural members of Armco steel buildings also will be installed.

Substantial space will be provided for pilot plant equipment for producing and processing steel. This equipment will include furnaces for strip annealing; a continuous strip line for varying conditions for a variety of surface treatments such as cleaning, electroplating and metallic and nonmetallic coating; and strip rolling equipment with coilers and other features for tension rolling.

Other new and advanced equipment will be added to present facilities to handle the increasing volume and variety of research projects.

In addition to Middletown, Armco has research facilities in three other locations. At Baltimore, Md., the company conducts research in stainless steel. The National Supply Co., Pittsburgh and Union Wire Rope Corp., Kansas City, Mo., have separate research laboratories. National Supply and Union Wire Rope are both Armco subsidiaries.

Construction of the Middletown addition is expected to get underway immediately. The project will be completed early in 1961.

GE AWARDED WISCONSIN AND FORD CO. CONTRACTS

△ General Electric Co. has received a $1,800,000 order for the complete electrical system for a new billet and merchant mill to be installed at the Wisconsin Steel Works of International Harvester Co.

Included in the system are 11 motors ranging from 400 to 1200 hp, each equipped with individual speed regulators.

Shipment of electrical equipment for the 14-stand continuous bar mill is scheduled for the fourth quarter of 1959 with installation expected in the second quarter of 1960.

General Electric Co. has also received a $7,000,000 order to furnish complete electrical systems for two Ford Motor Co. metal rolling mills. Both mills are located at Ford's Rouge plant, Dearborn, Mich., which produces sheet metal for automobile bodies.

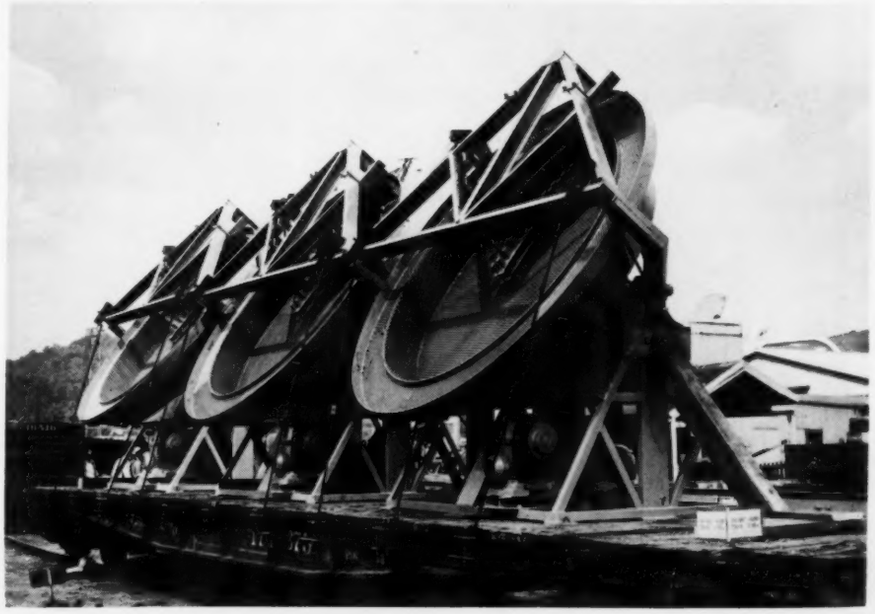
One of the mills—a new four-stand cold strip mill—is part of Ford's current modernization and quality improvement program. The other—a six-stand, 66-in. hot strip finishing mill—is an existing facility which is being expanded and modernized.

Five stands of the hot strip mill will be driven by new 5000-hp motors fed by individual 4000-kw rectifier power supplies, while the sixth will use an existing 4000-hp motor powered by a new 4000-kw rectifier. A speed-regulator system, acting through rectifier voltage, will be installed to cut mill setup time and improve over-all mill performance under impact loads.

Included in the over-all control system will be the new General

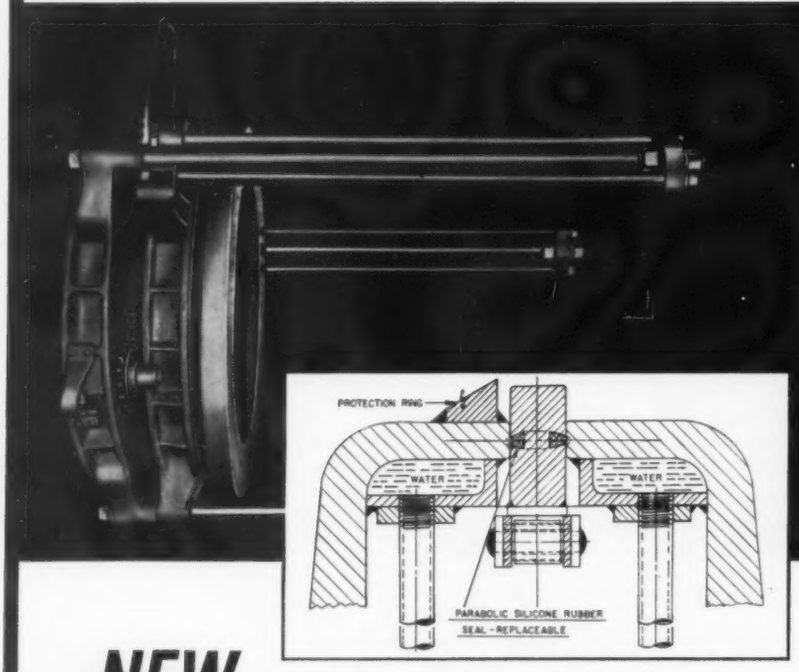
MIXING DISKS ENROUTE TO ZINC PLANT

These three mixing disks were recently shipped by Dravo Corp. to St. Joseph Lead Co., Monaca, Pa. The 8-ft 6-in. diam disks will prepare a mixture of roasted zinc concentrates, fines, flue dust and coke breeze for agglomeration on the plant's sinter machines. Each disk will turn out about 25 tons of mix per hour. After sintering, the material will be charged to electric furnaces for reduction to zinc.



World's First

Water-Cooled, Silicone Rubber-Seated GOGGLE VALVE



NEW... GAS-TIGHT Service for High Pressure Furnaces

Designed for use between dustcatcher and washer, this valve features parabolic silicone rubber seats in the goggle plate, and water cooled flanges. Design provides a tighter, more gas-proof seal than is possible with metal-to-metal seals. *Write for Bulletin V-200.*

BAILEY *Thermal Expansion* GOGGLE VALVES

WILLIAM M. BAILEY COMPANY • 1221 BANKSVILLE ROAD • PITTSBURGH 16, PA.

Electric automatic gage control which will use gage-meters on three stands to provide accurate thickness control from entry to exit.

The four-stand tandem cold strip mill will be driven by four 5000-hp twin drives and one 1200-hp double-armature reel motor, all powered from individual stand generator supplies. An x-ray type of automatic gage control will be used to maintain desired strip thickness.

Electrical equipment is scheduled for shipment in the first quarter of next year. Startup is expected by the fourth quarter of 1960.

GRANITE CITY FURNACE UNDER CONSTRUCTION

△ Construction of a large new blast furnace at the Granite City Steel Co. is now underway.

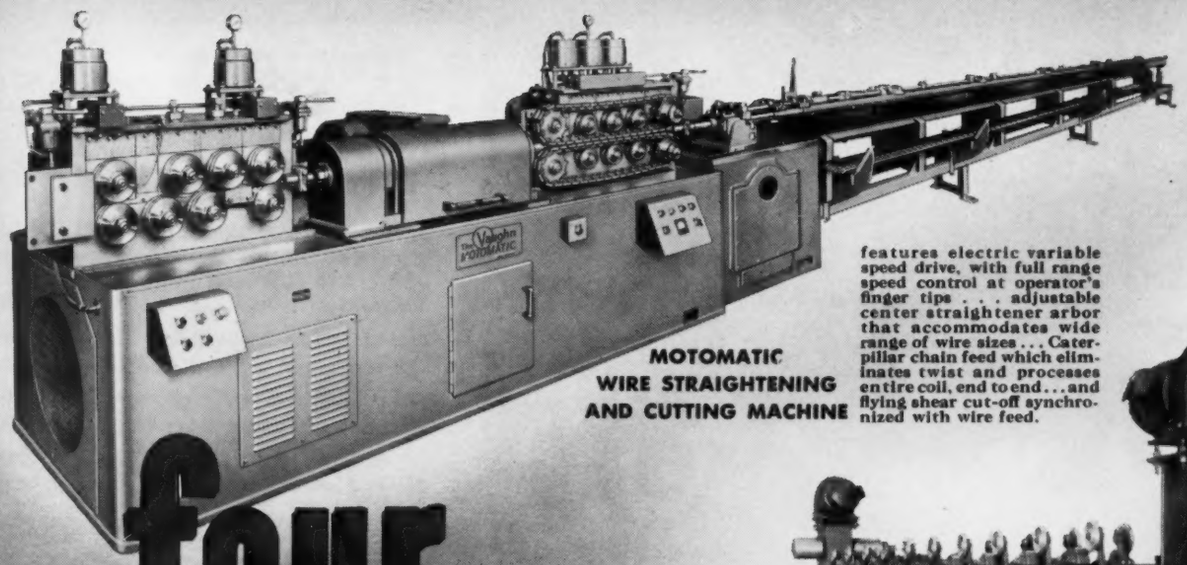
The new furnace will replace the older Granite City's two blast furnaces. With a hearth diameter of 28 ft, the new furnace will be able to produce 1800 tons of pig iron a day, twice as much as the furnace that will be torn down. When it is completed—July 1, 1960, is the scheduled completion date—Granite City Steel will be able to produce 3000 tons of pig iron a day, or 1,100,000 tons a year.

The company's open hearth furnaces now have a rated capacity of 1,440,000 tons of steel a year. This will go up to 1,584,000 tons next January 1, as a result of plant improvements completed recently under an earlier expansion program.

The general contractor on the blast furnace construction is Koppers Co., Inc.

Assembling a major part of the blast furnace off site, an unusual method of construction, is being done to keep to a minimum the time during which Granite City will have only one blast furnace supplying pig iron for its open hearth furnaces.

The old blast furnace will be blown out about March 1, and will be torn down immediately. Its foundation will be rebuilt and strengthened. Then the cone-shaped shell of the new furnace—plus a substantial part of the gas uptake pipes and other parts of the furnace superstructure above the shell—will be moved on steel rollers from the platform where it was built over



MOTOMATIC WIRE STRAIGHTENING AND CUTTING MACHINE

features electric variable speed drive, with full range speed control at operator's finger tips . . . adjustable center straightener arbor that accommodates wide range of wire sizes . . . Caterpillar chain feed which eliminates twist and processes entire coil, end to end . . . and flying shear cut-off synchronized with wire feed.

four NEW VAUGHN PRODUCTS

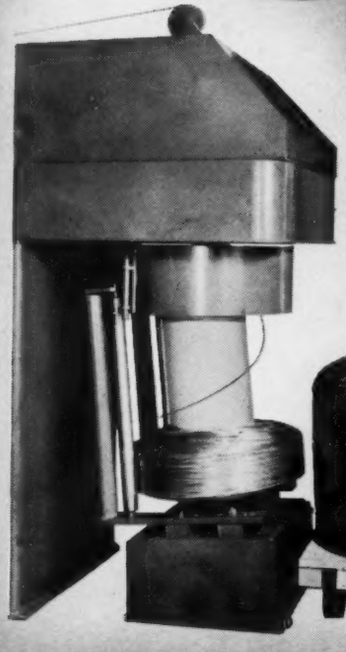
TO MEET THE WIRE INDUSTRY'S DEMANDS

- *for high speed, heavyweight coils . . .*
- *for wire laid in pay-off packs . . .*
- *for straight, precision-cut length wire . . .*

MULTI-PAK UNIT (20 strand)

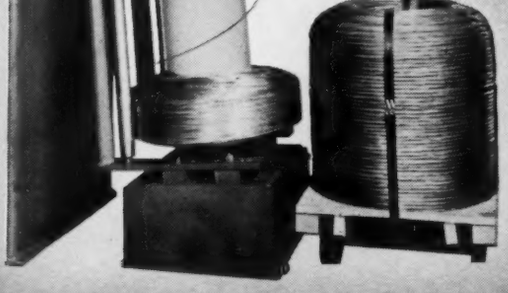
for faster, more efficient laying of wire in pay-off packs, drums or pails

MODERN **Vaughn®** EQUIPMENT

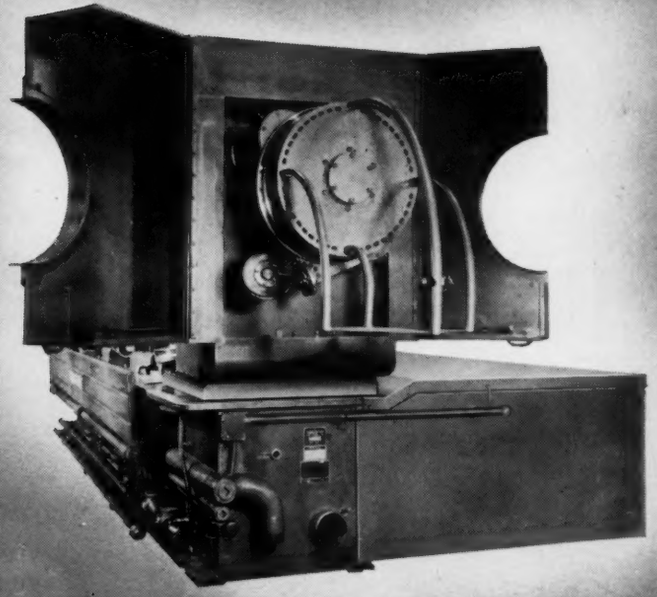


STATIONARY BLOCKS

for drawing and/or coiling to provide heavy weight compact coils. Available in either horizontal or inverted vertical designs.
16½ Gauge Galvanized Low Carbon Wire • Coil Weight—1611# Coil I.D.—14" • Coil O.D.—29" Coil Height—29"



Large Size Wire Bundle made on Stationary Block



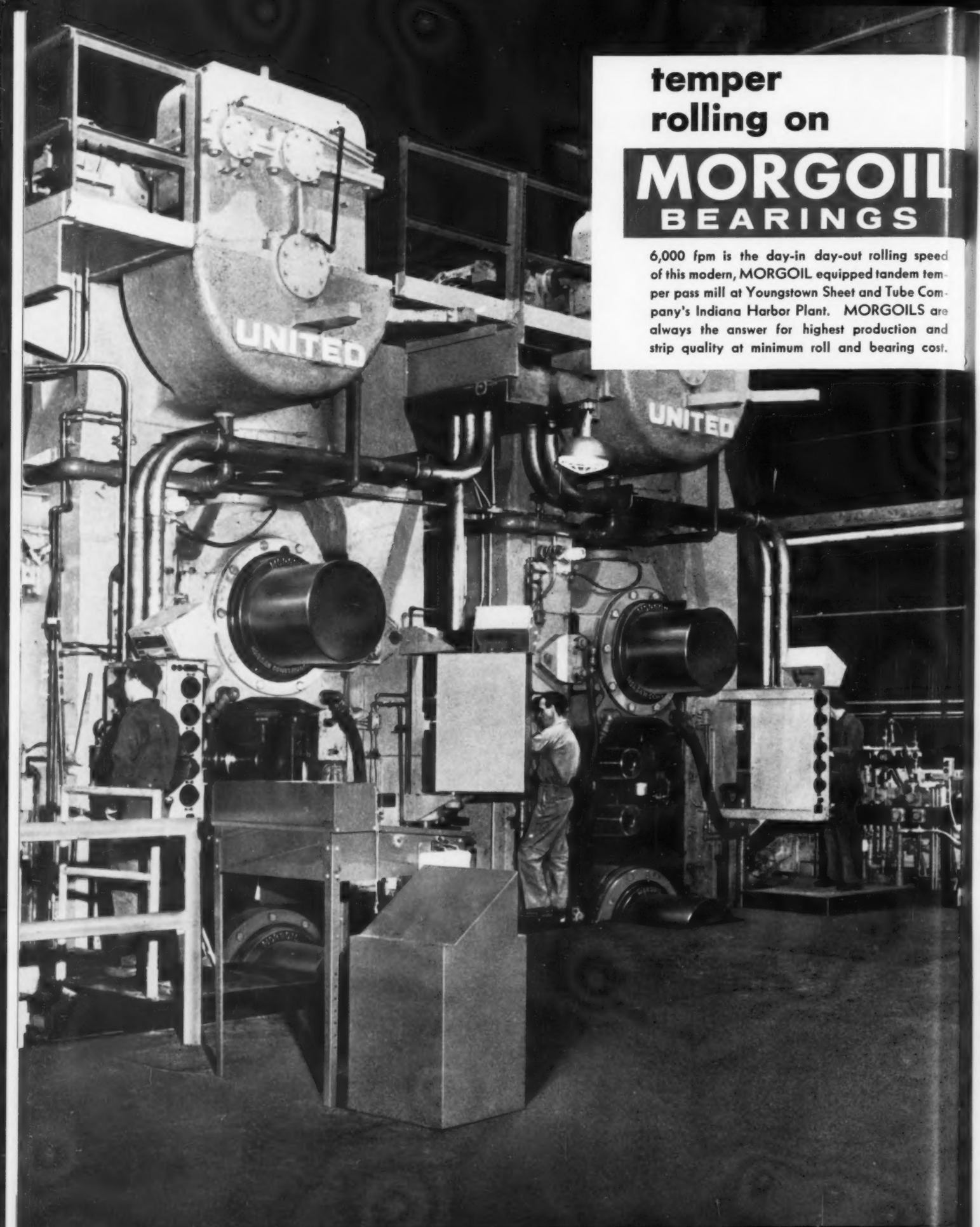
STATIONARY DRAWING BLOCK CONVERSION UNIT

which can be substituted for conventional finishing block on existing MOTOBLOX, to provide continuous drawing of heavy weight coils at high speed.

The VAUGHN MACHINERY COMPANY

CUYAHOGA FALLS, OHIO

COMPLETE COLD DRAWING EQUIPMENT—Continuous or Single Hole . . . for the Largest Bars and Tubes . . . for the Smallest Wire . . . Ferrous, Non-Ferrous Materials or their Alloys



temper rolling on MORGOIL BEARINGS

6,000 fpm is the day-in day-out rolling speed of this modern, MORGOIL equipped tandem temper pass mill at Youngstown Sheet and Tube Company's Indiana Harbor Plant. MORGOILS are always the answer for highest production and strip quality at minimum roll and bearing cost.

MORGAN CONSTRUCTION CO., WORCESTER, MASSACHUSETTS

ROLLING MILLS • MORGOIL BEARINGS • GAS PRODUCERS
WIRE MILLS • EJECTORS • REGENERATIVE FURNACE CONTROL

MB34

a trestle to the site occupied by the present blast furnace. The Eichleay Corp. will handle this heavy moving job. The total weight of shell and superstructure to be moved will be about 650 tons.

The gas cleaning system of the new furnace will include a dust-catcher, washers and electrostatic precipitators. The blast air that is blown into the furnace near the bottom will first be compressed, and heated in three cylindrical, gas-fired "stoves," each 127 ft high.

BEGINS CONSTRUCTION ON NEW MUNCIE PLANT

△ Construction of the Westinghouse Electric Corp.'s new multi-million dollar power transformer plant at Muncie, Ind., began November 5.

The T-shaped plant will occupy over 600,000 sq ft of floor space and will be located on a 300-acre site south of Muncie. The structure will be more than 1500 ft across the front. A main assembly aisle almost 900 ft long and more than ten stories high forms the leg of the "T."

Modern machinery, a wide variety of machine tools and test equipment, combined with automated production and more precise control of manufacturing process, are the basic factors of the new plant where extra high voltage transformers will be produced, and, at the same time, where costs will be held in line. This is the approach pursued in planning facilities layout for the new power transformer plant.

For example, the dual crane runway and the main assembly line are located in the "high bay" area. The first runway rails, 60 ft above floor level, accommodate the medium-size bridge cranes used to handle component parts for assembly; the second level rails, 80 ft above floor level, support large-size bridge cranes capable of lifting the completely assembled transformers.

Tandem operation of the dual cranes permits Westinghouse to fill transformers with oil on the line and eliminate the necessity for subsequent pumping oil out except prior to final dismantling for shipment. This innovation cut production time. Up to this time, lacking capacity to handle the weight of

BETTER SERVICE AND 10 MORE TONS OF IRON!

PITTSBURGH STEEL MILL

90 ton blast furnace ladle. Lined with 3½" of Hot Top Moldit Castable refractory — washcoated with Super #3000. *Still in perfect condition after 6000 tons of iron.* Lining thickness same as when installed. No metal build-up. No maintenance. Original Super #3000 washcoat still visible.

Plant reports that 3½" Hot Top Moldit lining replaced a 4½" firebrick lining.

Result: Ladle holds 10 tons more iron than previously.

HOT TOP MOLDIT CASTABLE

was originally introduced as a hot top lining castable which far outlasts brick or clay linings and which has unusual non-wetting and insulating properties. Other highly successful applications of HOT TOP MOLDIT include collars on treadwell ladles, floors of pusher-type annealing furnaces, blast furnace runners.

REFRACTORY & INSULATION CORP.

R&I

REFRACTORY BONDING AND CASTABLE CEMENTS
INSULATING BLOCK, BLANKETS AND CEMENTS

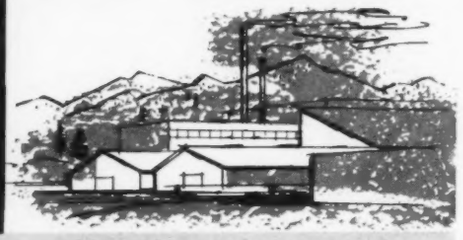
136 Wall St., New York 5, N. Y.

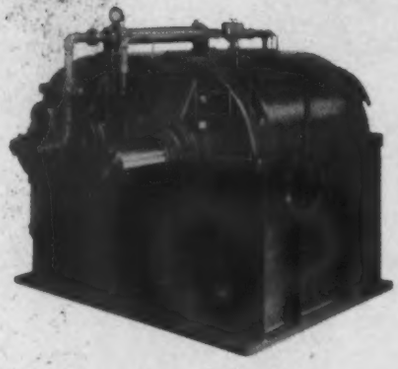
3-stand roughing mill train driven by a single motor using 3 special Western Gear combination pinion stand speed reducers to distribute power to housing locations.

BIG POWER–SMALL SPACE

Combination double reduction right angle reducer pinion stand, 3.7:1 ratio, rated 1500 HP AGMA Class 1 at 200 RPM input.

custom-engineered by **WESTERN GEAR!**





Two-speed herringbone reducer for midwest steel mill installation, ratios 1:1 and 1.5:1, rated 3500 HP AGMA Class 1 at 900 RPM input, driven by a 1750 HP motor.

As part of the recently completed plant expansion program of a major steel producer in the Seattle, Washington area, roughing mill stands were set in a widely separated continuous arrangement.
Problem: How best to locate large power feed shafts between reduction gears and mill stands.
Engineering and cost-reduction studies by Western Gear's Seattle Engineering Group resulted in the efficient mechanical power distribution sketched here. Western Gear plants and engineering facilities are ready to assist you in solving any problem of mechanical power distribution.

WESTERN GEAR CORPORATION
Industrial Products Division
P.O. Box 126, Belmont, California
Please send SpeedMaster Speed Reducer Bulletin 5802.

NAME_____
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ADDRESS_____
CITY_____ STATE_____

5802

loaded transformers, it has been necessary to fill them with oil for initial test—a two-day operation; empty them for handling after initial tests are completed; and later refill them for the corona and sound tests.

The test center is designed to provide convenient and adequate equipment to make complete commercial and development tests on the largest units to be built in the next decade. And the arrangement is for expansion if the need arises. All tests include power loss measurements, temperature runs, impulse tests on completely assembled units in excess of 600-kv and sound level and corona tests.

The large turntable at the entrance to the sound measurement and corona test room—78 ft long, 78 ft wide and 70 ft high (inside dimension)—at the end of the assembly line swings the power transformers the necessary 90 deg to take them through the door of the test room. Complete sound measurements can be made on transformers weighing more than 600 tons.

Specially designed railroad cars called "Schnable Cars" capable of carrying over 700,000 lb will be used and will permit shipping bigger single units with lower cost per kva.

DOW CHEMICAL FORMS NEW SERVICE DIVISION

△ Formation of a new division to handle industrial chemical services has been announced by the Dow Chemical Co.

Known as the Industrial Service Division, it will take over solvent cleaning functions performed by the company's Dowell division for many years, and also will provide services and products in the municipal and industrial waste and water treatment areas.

John G. Staudt, executive vice president of Dowell, will be president. John S. Spriggs, staff assistant in the Chemicals Department, will be vice president and general manager.

The division is scheduled to begin operations December 1, 1959, with headquarters in Cleveland, Ohio.

Dowell has been chemically cleaning and conditioning industrial equipment — boilers, condensers, cooking systems and the like—on a commercial basis since 1939.

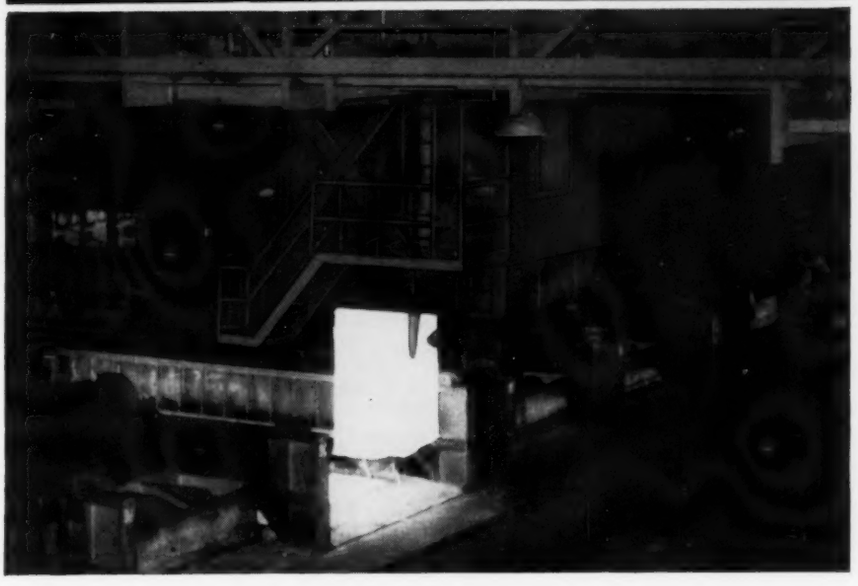
In announcing the new division, Dr. Leland I. Doan, president of the Dow Chemical Co., said "the industrial chemical service successfully developed by Dowell has grown steadily over the years and now has reached the point where a separate organization is required to handle its activities.

"At the same time, because of the rapid development of chemical products useful in the municipal and industrial waste and water treatment areas, it seems logical to have the same organization take on the service-selling of those products and provide consulting service in those areas."

TO PROVIDE SLABBING MILL FOR FRENCH FIRM

△ Mesta Machine Co. has begun work on a 45 x 120 in. slabbing mill and related equipment for Societe Dunkerquoise de Siderurgie of Paris. The high-lift mill will be installed at the firm's new plant in Dunkirk,

Although exposed to high ambient temperatures, this cab is easily kept at 80°-85° F. It means safer and better working conditions and improved production.



Hot enough to cook a crane operator

BUT IT DOESN'T HAPPEN HERE!

The man inside this crane cab is fresh and efficient because his cab is Lintern Air Conditioned. In spite of that hot ingot, the operator enjoys a comfortable temperature the year around. He's free of fumes, gases, dirt and the fatigue that excessive heat brings on.

Thanks to **LINTERN AIR CONDITIONING**

hundreds of plants have improved efficiency. Right now Lintern is busy modernizing the crane cabs and pulpits of dozens of plants. This means they'll enjoy more output, less labor turnover, a greater return on their capital investment.

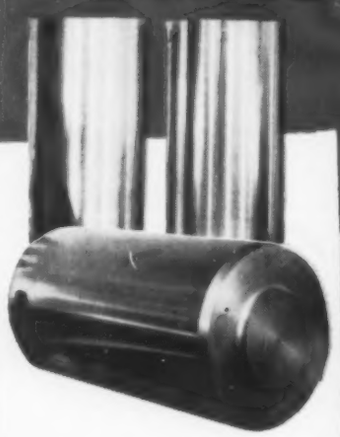
Maybe you should do this, too. It costs nothing to find out.

Write for Bulletin AC-573.

Larco, inc.
DISTRIBUTOR OF LINTERN CORPORATION PRODUCTS
ROUTE 20 EAST • PAINESVILLE, OHIO

RED CIRCLE Rolls ALLOY-CHILLED

Hyde Park RAMS



for all types of HYDRAULIC EQUIPMENT

Hyde Park Rams are available in Chilled or Alloy Iron.

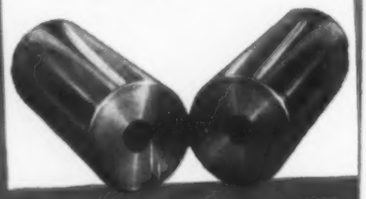
Furnished in hardness range to meet your specification . . . ground to your required size.

On your next replacement of Rams—or for new equipment—consult us. Our engineers will be glad to assist you.

Red Circle Rolls for every Purpose

Rolling Mill Equipment

Gray Iron Castings up to 80,000 lb.



Hyde Park FOUNDRY and MACHINE CO. HYDE PARK Westmoreland County, Pa.

Rolls
Rolling Mill Equipment
Gray Iron Castings

France, for the rolling of slabs 3 to 12 in. thick, 40 to 65 in. wide, and 75 to 118 in. long from ingots weighing up to 25 tons.

The installation will include a rope-driven ingot buggy of the roller table type, ingot receiving table, transfer table, scale table, a 25 metric ton ingot scale of the load cell type with automatic printer, waiting table for holding weighed ingots awaiting access to the mill, mill approach table, front and rear mill tables, mill runout table, scarfer approach table, flame shear runout table and a 25 metric ton slab scale.

The special alloy cast steel rolls of the slabbing mill will be mounted in tapered roller bearings, and connected by universal spindles to individual 5000 hp motors. The mill will be equipped with a double manipulator, cast steel scale chute, hydraulic roll balance, hydraulic sled-type roll changing rig and screwdown mechanisms. A recirculating oil lubricating system and centralized grease system will also be included in the design.

ADD VENTILATING UNITS AT CAMPBELL WORKS

△ As part of a modernization program at the Campbell Works of Youngstown Sheet and Tube Co., the Sturtevant Division of Westinghouse Electric Corp. is supplying fans and filter equipment to force-ventilate twelve main-stand motors and two large motor-generator sets.

The original updraft ventilating system at the plant's 79-in. hot strip mill is being changed to a downdraft non-recirculating system. However, it will be possible to recirculate the warm air from the machines back to the motor room during winter operation.

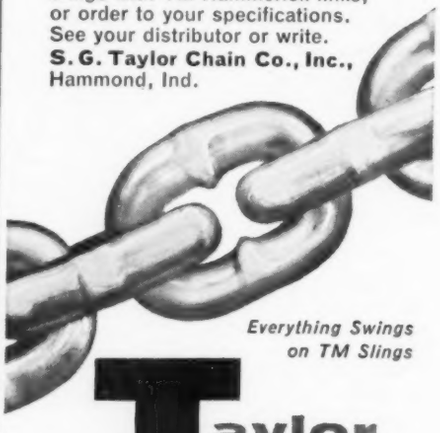
Three 20-ft bays of roof area will be redesigned to house the supply air system. Twelve vertically mounted vaneaxial fans will draw 825,000 cfm of air through filters to the main motor room area.

In the basement, seven centrifugal fans will draw approximately 630,000 cfm through the motors and generators. Three Tubeaxial and four Airfoil centrifugal fans also located in the basement, will then exhaust this air to atmosphere.

The total connected horsepower to the fans will be 1515 hp.

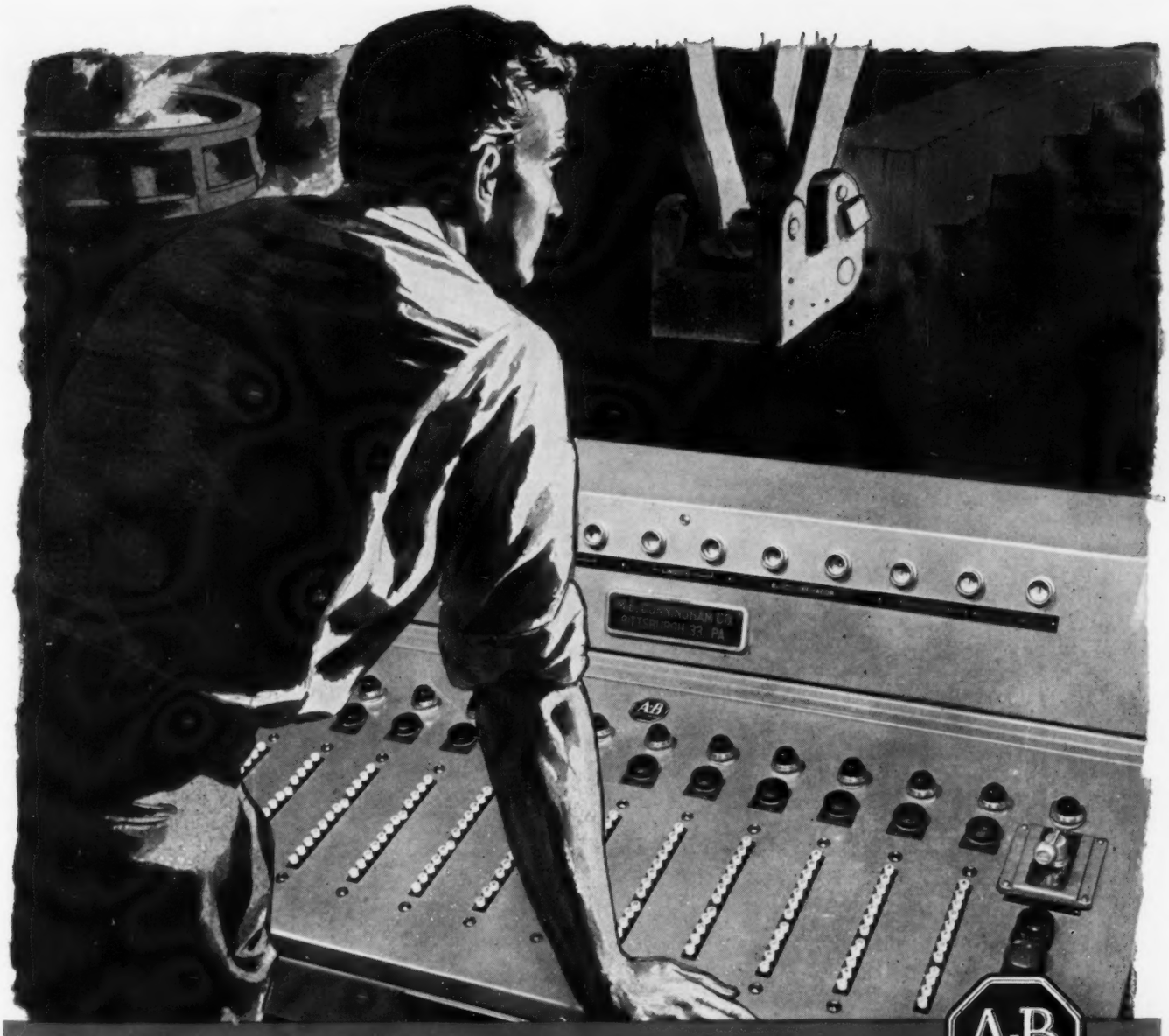
TOPS in STRENGTH

You'll find TM Alloy Chain is used wherever rugged "brute strength" is a requisite. For example—the working load limit of ¾" TM Alloy is 23,000 pounds. It's tougher, safer and far less costly than other grades of chain tested. Assemble your own slings with TM Hammerlok links, or order to your specifications. See your distributor or write. **S. G. Taylor Chain Co., Inc.,** Hammond, Ind.



Everything Swings on TM Slings

Taylor Made CHAIN SINCE 1873



Automatic marking of hot steel . . .

Controls by ALLEN-BRADLEY, of course

Here's an interesting job that's gone "push button"—stamping heat numbers on hot steel! Now, from a remote console, the operator automatically sets numbers on the marking head and propels it against the steel. The controls, *of course*, are Allen-Bradley because they provide the continuous reliability that is essential to this production.

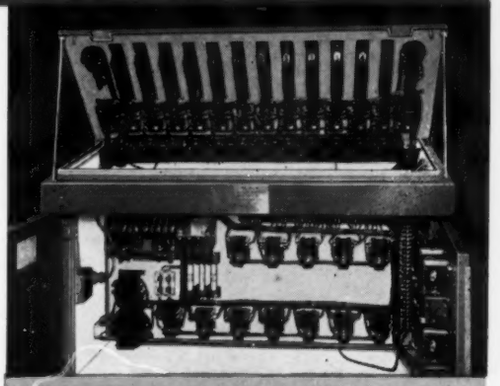
The simple, ONE moving part solenoid design of A-B starters and relays assures millions of trouble free operations. And the double break, silver contacts—used on all A-B control—eliminate costly downtime for maintenance. Keep your production lines rolling . . . insist on Allen-Bradley *quality* motor control. You cannot do better!

Allen-Bradley Co., 1343 S. First St., Milwaukee 4, Wis.
In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

ALLEN-BRADLEY

Member of NEMA

Quality Motor Control



The relays and push buttons used in the remote control console of this M. E. Cunningham Marking Machine are all standard Allen-Bradley catalog items.

For Hazardous Locations

Heavy-Duty, Cam-Operated

PUSH-BUTTON STATIONS

600 Volts
A-C or D-C

● The Euclid Electric & Mfg. Co. (Madison, Ohio) has added a complete new line of Pendant Push-Button Stations for all applications that necessitate NEMA Types 7 and 9 enclosures to meet hazardous-location requirements. Designed for heavy-duty applications, these cam-operated Stations are rated 600 volts, a-c or d-c. They are available from one to five speed-points in each direction for a total of eight circuits to provide for practically an unlimited number of different sequences of operation.

Sturdily constructed to withstand hard usage and abuse, their small cross-section permits comfortable, non-fatiguing, one-hand operation. Where required, a bottom holding handle can be supplied. The dense cast-aluminum enclosure can be readily opened for inspection of the silver-to silver contacts without disturbing any wiring. The conduit hole is threaded and a double-suspension cable hanger is provided.

Extra features include heavy-duty, control-circuit toggle disconnects, pilot lights, selector switches, and maintained-type contacts.

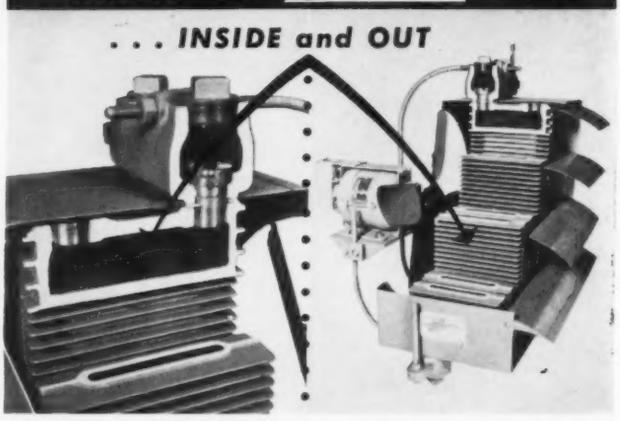
ASK FOR BULLETIN 2017

THE EUCLID ELECTRIC & MFG. CO.
MADISON, OHIO

THE EUCLID ELECTRIC
EUCLID
AND MFG. CO., MADISON, O.

it's the material that makes the difference . . .

. . . INSIDE and OUT



CORROSION - Inside and Out - causes heating equipment failures!

BUT NOT WHEN YOU USE

GRID

cast iron construction

- **UNIT HEATERS**
- **BLAST HEATERS**
- **RADIATORS**

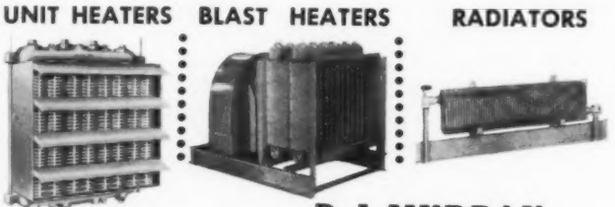
Designed for operation on steam pressure up to 250 PSI 450° temperature

CORROSION internally, caused by electrolytic action as in copper tubes, can't happen in GRID's cast iron steam chambers and headers. Nor can acid condensate corrode the bottom connections. Cast Iron, internally, resists corrosion.

CORROSION externally, caused by acid fumes cannot destroy GRID's cast iron finned heating surface. Widely spaced fins cast integral with the steam chamber will not corrode externally.

Send for Catalog 956 . . . The complete story on Grid Unit Heaters, Blast Heaters and Radiators.

UNIT HEATERS **BLAST HEATERS** **RADIATORS**



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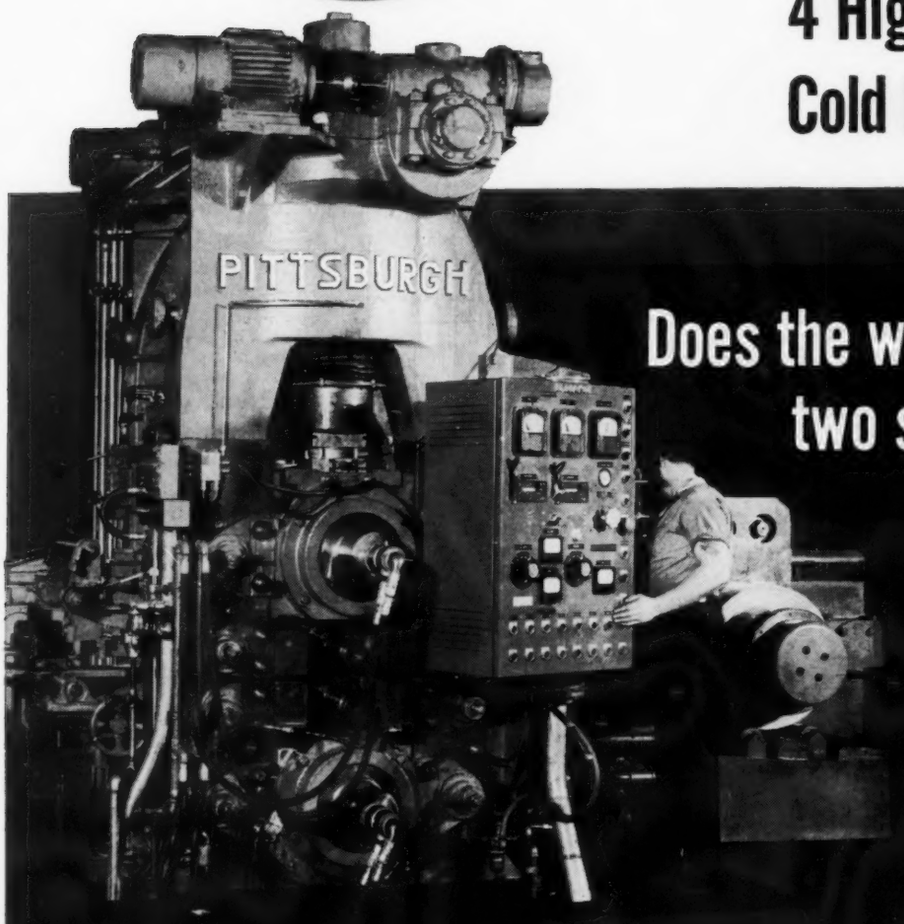
Combination 4 High/2 High Cold Mill . . .



Does the work of two separate mills

"Precision" and "Versatility" are the words that best describe the new combination 2 High 4 High Cold Mill designed and built by PITTSBURGH to secure precision gauge, temper and finish for the ferrous and non-ferrous industries. As a 4 High Mill, it is used for cold reducing; as a 2 High Mill, it is used to acquire the desired temper and finish. Several desirable design features are incorporated to keep roll change time to a minimum. Low initial cost and economical operation are attractive plus values.

"Electric and open hearth steel castings from 1 lb. to 100 tons"

HEAVY MACHINING FACILITIES

Our plant is equipped with a superior complement of well diversified machine tools that are available on a continuing basis for economical machining of heavy castings or the manufacture of auxiliary rolling mill equipment, such as heavy mill tables, furnace pushers, slab depilers, downcoilers, ingot buggies, slab transfers, etc.

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WHY KEEP THE UPKEEP?

MAINTENANCE COSTS		TIME OUT
January	VERY HIGH	22 hours
February	STILL HIGH	17 hours

Switch to the

HKP® PORTER ONE-HOSE *Hydraulic* ROD and BAR CUTTER

IT'S PRACTICALLY . . .

MAINTENANCE FREE!

To slash those sky-high costs on bar and rod cutting operations and maintenance in your mill you need the superbly efficient, rugged, trouble-free one-hose PORTER HYDRAULIC ROD and BAR CUTTER. An all-job team of 3 Cutterheads and 5 Power Unit sizes offers just the right combination to handle any of your cutting work — faster better and at far lower cost. Here's why:

CONTINUOUS TROUBLE-FREE OPERATION

CUTTERHEAD PROTECTION — that eliminates constant "TIME OUT" and HIGH MAINTENANCE COSTS!

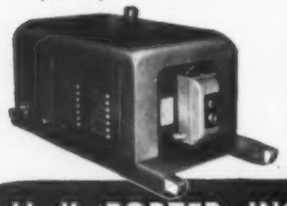
- **LONGER BLADES** with more bearing surface and rigid alignment eliminate side thrust and blade breakage.
- **FILTERED AIR** taken into the cylinder is forced out around the movable blade on each cut — eliminates the danger of dirt reaching bearing surface causing oil leakage and wear.
- **CONCENTRIC DESIGN** eliminates excessive wear of cylinder wall and ram.
- **LARGER CYLINDER AREA** allows the tool to cut capacity stock at a lower operating pressure, resulting in longer life for seal and hose.
- **SAFE, 12 VOLT CONTROL SWITCH** at the cutterhead gives instant finger-tip performance.
- **"KEY-POINT"** wear and replacement reduced to the minimum because of these exclusive HKP features.

A TRUE HYDRAULIC SYSTEM with these efficient, maintenance-saving features:

- **CONTROL VALVE** big and accurate enough for all industrial work. Solenoid operated.
- **EASY TO CHANGE RESERVOIR TYPE 10-MICRON OIL FILTER.**
- **PLUS** many other exclusive HKP features.

Ask to have a Porter Engineer tell you how the 3 CUTTERHEAD sizes and 5 HYDRAULIC POWER UNITS can provide the exact combination for your requirements.

OR — WRITE FOR COMPLETE PORTER HYDRAULIC ROD and BAR CUTTER FOLDER.



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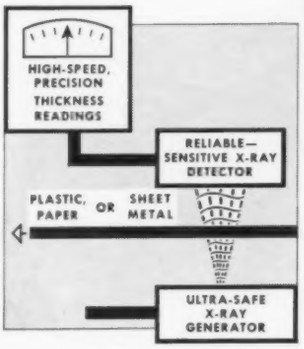
Control Thickness and Profile of Foils and Films with *NEW* Pulsing Type SHEFFIELD MEASURAY GAGE

Sheffield Measuray Gage Model 25 PT continuously checks to "millionths" the thickness or profile of plastic films, paper, foil or sheet metal as it leaves the mill rolls at high speed. No contact between gage and material.


HIGH-SPEED, PRECISION THICKNESS READINGS
RELIABLE— SENSITIVE X-RAY DETECTOR
PLASTIC, PAPER OR SHEET METAL
ULTRA-SAFE X-RAY GENERATOR

Principal Features

- **All-Electronic System assures high-speed response and accuracy**
- **Narrow X-ray beam for profiling**
- **Short pulsing of X-ray assures extra safety**
- **Modular construction facilitates quick, easy maintenance**

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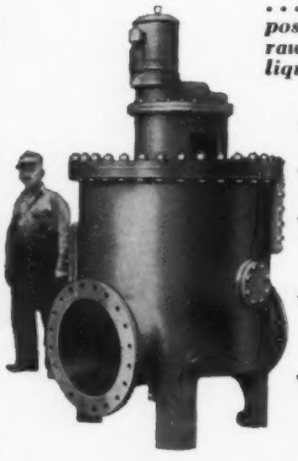
. . . for efficient removal and disposal of suspended particles from raw or process water and other liquids



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- ✓ Installation on pressure or suction side of pump
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- ✓ Large variety of straining media

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...INCORPORATED

CAPACITY

... capacity to design, produce, install and operate
complete systems for separation, purification and
liquefaction of gases – systems that provide
profitable advantages and opportunities throughout industry.

Liquefied gases from Air Products equipment supply all major U.S. missiles.

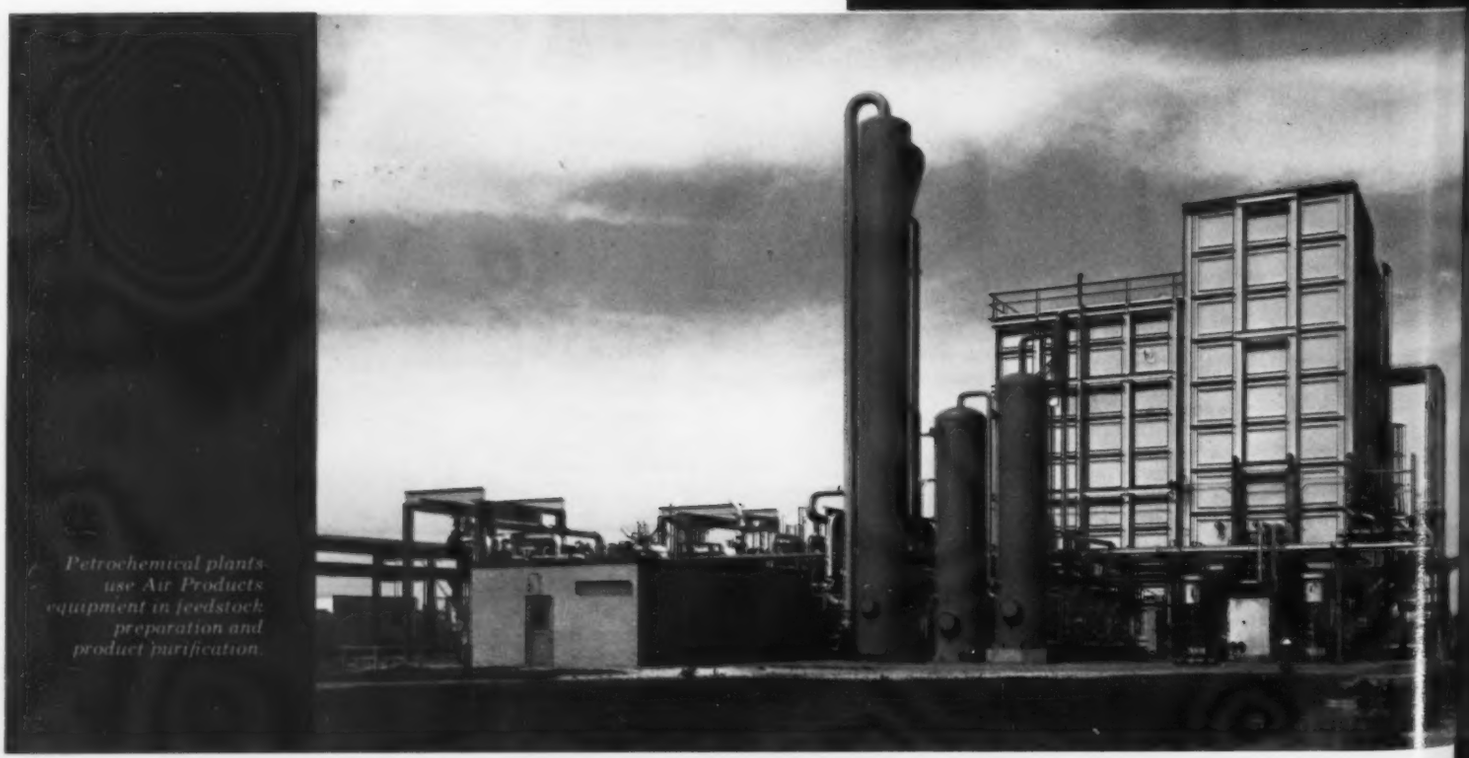
HOW THE MILITARY SERVICES use Air Products CAPACITY

Large-scale low-temperature systems, ultra pure gases and liquids, and a broad range of specialized cryogenic "hardware" are supplied by Air Products to the military. When large quantities of liquefied gases were needed for rocket engine development and missile testing, Air Products quickly designed, manufactured and put on stream complete production facilities. Typical facilities paid for themselves in less than a year's time. Air Products also provides a broad line of portable air separators for field and shipboard use . . . and has advanced the development of exotic fuels. And, Air Products produces advanced design liquefied-gas pumps, cryogenic storage and transfer systems, electronic cooling devices and refrigeration and distillation equipment for military uses.

YOU will find here tangible evidence of a growing technology. Applying "Cryogenics" (the science of low temperatures) and engineering broad new routes to low-cost, high-purity industrial gases is the main business of Air Products.

Air Products combines original research knowledge with engineering and manufacturing capabilities and substantial operating experience. These integrated activities have

These companies and many others are the beneficiaries of major facilities provided by Air Products:
Acme Steel • Bethlehem Steel • Brazilian National Steel • Celanese • Dow Chemical • du Pont • Grace Chemical • Great Lakes Steel



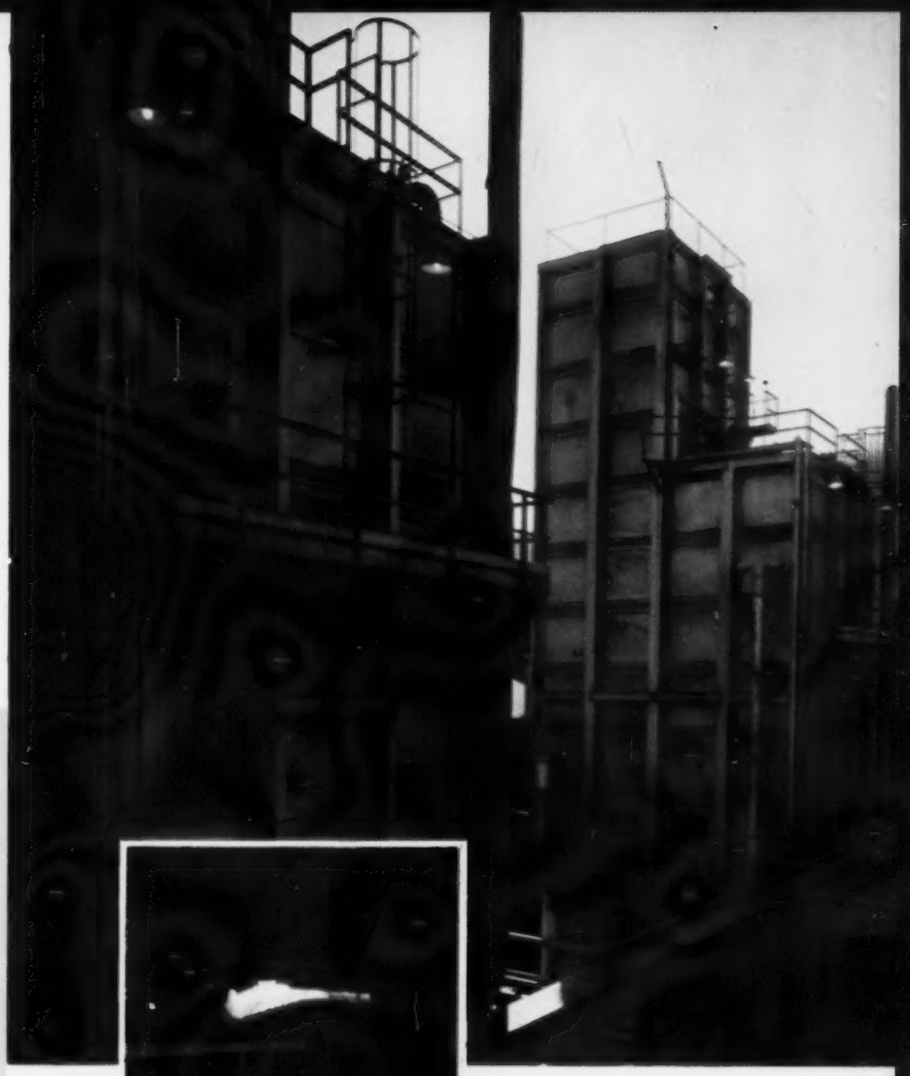
Petrochemical plants use Air Products equipment in feedstock preparation and product purification.

HOW THE STEEL INDUSTRY uses Air Products CAPACITY

In the blast furnace, the open hearth and the new converter processes — Air Products oxygen efficiently increases steel mill capacity. Annealing nitrogen and other gases are also provided on a low-cost tonnage basis.

Air Products' complete gas supply systems are installed at steel mills without capital investment or operating worries on the part of the users. Continuity and reliability of supply are assured. On-site facilities pioneered by Air Products reduced the cost of oxygen 80% in 12 years — transforming oxygen from a costly chemical to a practical working utility.

Further progress marks on-the-job development work now continuing around the clock at major steelmaking facilities. Entirely new metallurgical techniques . . . and new profits . . . are available through Air Products.



helped provide many Air Products customers with distinct competitive advantages.

Air Products is the world's leader in APPLIED CRYOGENICS — the practical and profitable use of low-temperature science for industry.

Perhaps this CAPACITY can help solve your problems — in cryogenics, in industrial gas supply systems, or in some new area where "ground rules" are yet to be established.

Air Products pipeline oxygen serves the Basic Oxygen Furnace Process.

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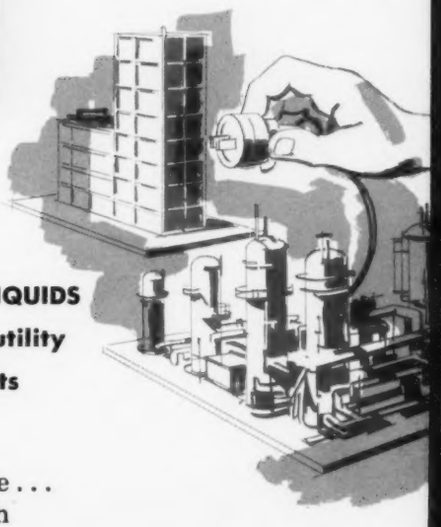

HOW THE CHEMICAL INDUSTRY uses Air Products CAPACITY

Air Products low-temperature systems permit many modern chemical plants to improve operating efficiency and end-product quality — and to develop new processes and products. This results from the ready availability of low-cost tonnage quantities of oxygen, nitrogen, hydrogen, ammonia and methanol syn-gas, carbon monoxide and hydrocarbons such as purified methane, acetylene and ethylene. Low-temperature separations of gaseous mixtures now make it practical to recover valuable components from natural gas, refinery off-gases, coke-oven gas and other "waste" gases. The versatility of cryogenics—as applied by Air Products—works profitably for the chemical industry today . . . offers unparalleled future opportunity in this fast-growing industry.

HIGH PURITY GASES AND LIQUIDS —available like any other utility with the help of Air Products CAPACITY

. . . The supply is dependable . . . the price guaranteed . . . with Air Products on the job.

Air Products
. . . INCORPORATED

"ULTIMATE" FUEL ON TONNAGE SCALE
... from pilot operation to tonnage production through Air Products CAPACITY

Liquid hydrogen, identified by the Air Force as an "ultimate" chemical fuel with three times the energy content of present fuels, is in production at this facility in Palm Beach County, Florida. Built and operated for the Air Force by Air Products.

Perhaps you, too, can profit from

Air Products CAPACITY*

* To find the new opportunities Applied Cryogenics may offer in the manufacture, separation and purification of Industrial Gases.

* To provide integrated research, engineering, manufacture and operation...complete services under a single responsibility.

* To forecast accurately and guarantee total cost, superior performance and reliability.

* To put entire gas supply complexes to work for you *without capital investment on your part.*

Air Products CAPACITY has helped our customers to step out ahead of competition in familiar fields... to open up entirely new areas of opportunity through new products or processes. A letter or telephone call will put Air Products CAPACITY to work for you.

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Information is available on: superconductivity • frozen free radicals • biological preservation • environmental control • low-temperature catalytic reactions • infrared detection • masers • purification and liquefaction of: argon • carbon monoxide • ethylene • fluorine • helium • hydrogen krypton • methane • neon • nitrogen • nitrogen trifluoride • oxygen • oxygen difluoride • ozone • xenon

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46 x 90 inch Universal Slabbing Mill at the Fontana Works of Kaiser Steel Corporation.

BLAW-KNOX

UNIVERSAL SLABBING MILLS

Blaw-Knox designs and builds slabbing-blooming mills in a complete range of sizes in universal and high lift types. Other Blaw-Knox equipment for the metals industry includes complete rolling mill installations and auxiliary equipment for ferrous and non-ferrous metals, iron, alloy iron and steel rolls, Blaw-Knox Medart cold finishing equipment, carbon and alloy steel castings, fabricated steel plate or composite design weldments, steel plant equipment, and heat and corrosion resisting alloy castings.

BLAW-KNOX

BLAW-KNOX COMPANY

Foundry and Mill Machinery Division

Blaw-Knox Building • 300 Sixth Avenue

Pittsburgh 22, Pennsylvania

Operator reads Speedomax H chart record

Hot ingot is pulled at Inland

New Trend in Soaking Pit Practice

Accelerated heating of Inland Steel's biggest ingots

Fast heating of giant 20-ton ingots, close temperature control and excellent scale deposition are some of the advantages that Inland Steel is getting from 6 batteries of 18 new Salem-Brosius soaking pits at Indiana Harbor Works.

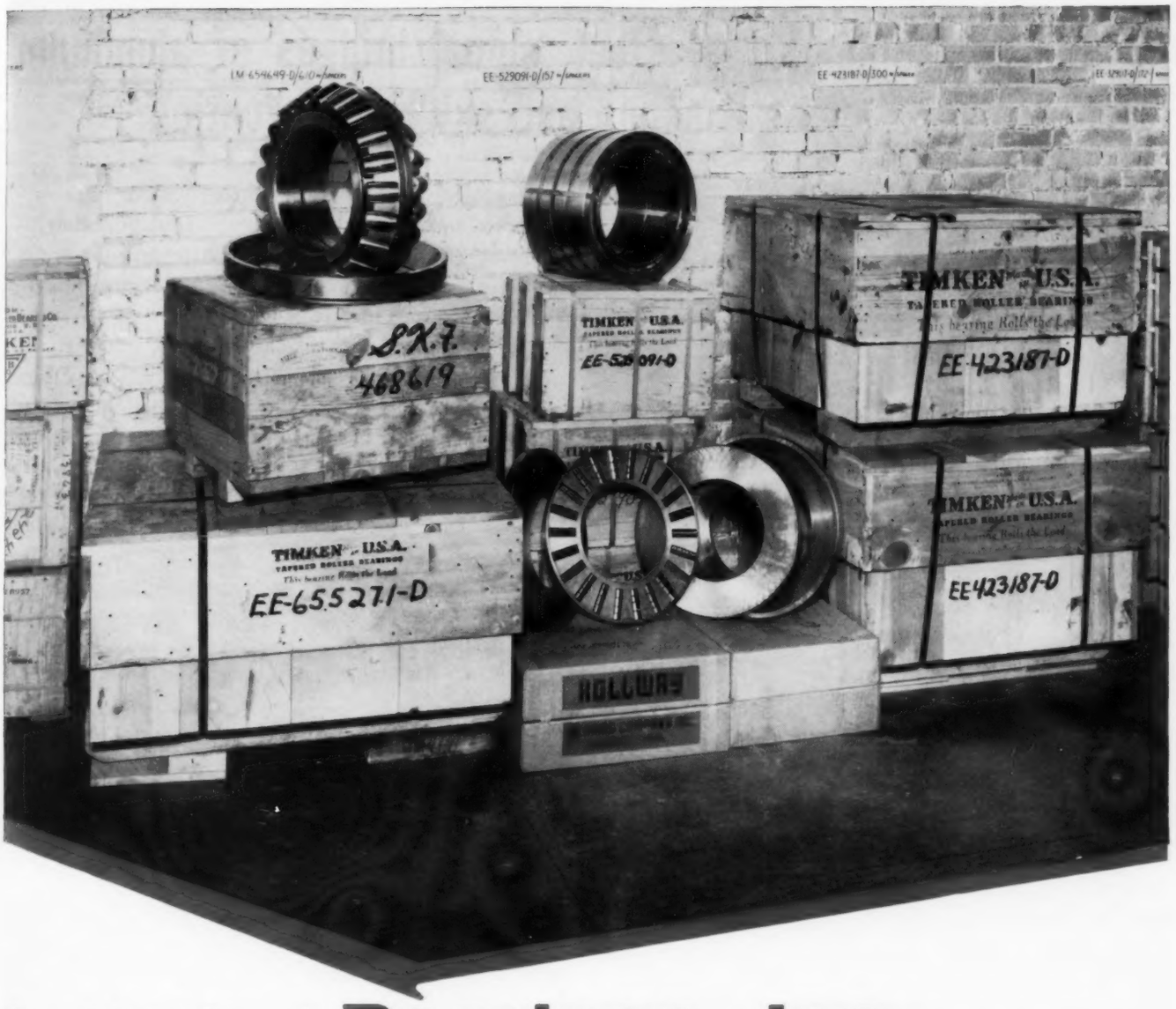
These advantages are, in part, gained by new accelerated heating systems that feature the Speedomax® Type H temperature controller.

When cold ingots are charged, the pit operator sets a predetermined accelerated heating program by means of a timer on his central control panel. During the period of fast heating, extra fuel is supplied to the pits, driving pit temperature to an accelerated control point. This higher point is determined by metallurgical conditions and may be reset as conditions demand. As the ingot soaks up this extra heat, and the fast-heating period is completed, fuel is cut back and Speedomax H returns the pits to normal control temperature for the remainder of the soak period.

Because of this efficient control system, heat-up time is cut and the production of ingots is increased, assuring that the new rolling mills can operate at maximum output.

Because of their reliability, L&N temperature control instruments are specified by a majority of soaking pit users and manufacturers. So, when you modernize—or build soaking pits—ask your L&N Field Engineer to show you what L&N temperature controls . . . and our equally dependable combustion controls . . . can do for you. Or write to 4942 Stenton Avenue, Phila. 44, Pa.

LEEDS & NORTHRUP
Instruments — Automatic Controls • Furnaces



In stock at Bearings, Inc.
. . . steel mill work roll, back-up roll, roll neck bearings ready to ship!

If you know bearing numbers—a check of those in the photograph will tell you they are among the largest and most expensive precision, steel mill bearings made. These and many other steel mill bearings, large and small, are ready in Bearings, Inc. stock for immediate delivery!

Why carry heavy inventories of these expensive bearings? Our large stocks for replacement "on the mill" or "off the mill"—bearings for all types of mill tables, coils, cranes and mill motors as well as ingot car bearings and pallet wheels can be ordered and delivered immediately!

No other bearing distributor carries a comparable stock of steel mill bearings ready for every emergency. If you want steel mill bearings in a hurry, call or write NOW!

Shown in the photograph are only a few of the many steel mill bearings in stock. Left, a SKF Back-up Roll Thrust Bearing sits on a 2,000 lb. Timken Back-up Roll Bearing. Center, Timken Work Roll Bearings and Rollway Self-Aligning Thrust Bearings. Right, in boxes, are a pair of matched Timken Back-up Roll Bearings.

Providing bearing service in the North➤

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OHIO: Akron • Canton • Cincinnati • Cleveland • Columbus • Dayton • Elyria • Hamilton • Lima • Lockland • Mansfield • Toledo • Youngstown • Zanesville
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VIRGINIA: Richmond

Reactor core supports of steel, signal bridges of aluminum . . . evidence of B-L-H scope and skill in fabrication

Shown are stainless steel components of core supports for nuclear reactor being welded at B-L-H's Eddystone Division.

Traffic signal bridges or nuclear reactor core supports, 100-ton pressure vessels or a hub and shaft assembly for a wind tunnel—no matter how big or unusual or complex the fabricating job, whether ferrous or nonferrous metals, B-L-H's Eddystone Division can handle it—economically, swiftly, expertly.

The signal bridges (see illustration) were constructed of structural aluminum sections, plates and bars in conformance with the strictest specifications. There are 15 of these structures, and they are 84 feet long. In Eddystone's huge shop—13 bays, each 900 ft. long—handling these giants presented no problem.

The nuclear reactor core supports, fabricated of stainless steel, called for rolling, welding, stress-relieving, and extremely accurate machining. In spite of the close tolerances required, expert planning and accurate manufacturing permitted final assembly of the core and core components with ease and a minimum of selective preassembly.

Write us for a free copy of our illustrated Weldment Bulletin 7001. It will give you an excellent idea of the broad scope of our work.

Components of traffic signal bridges for Delaware River Turnpike Bridge in vast fabricating shop at Eddystone.

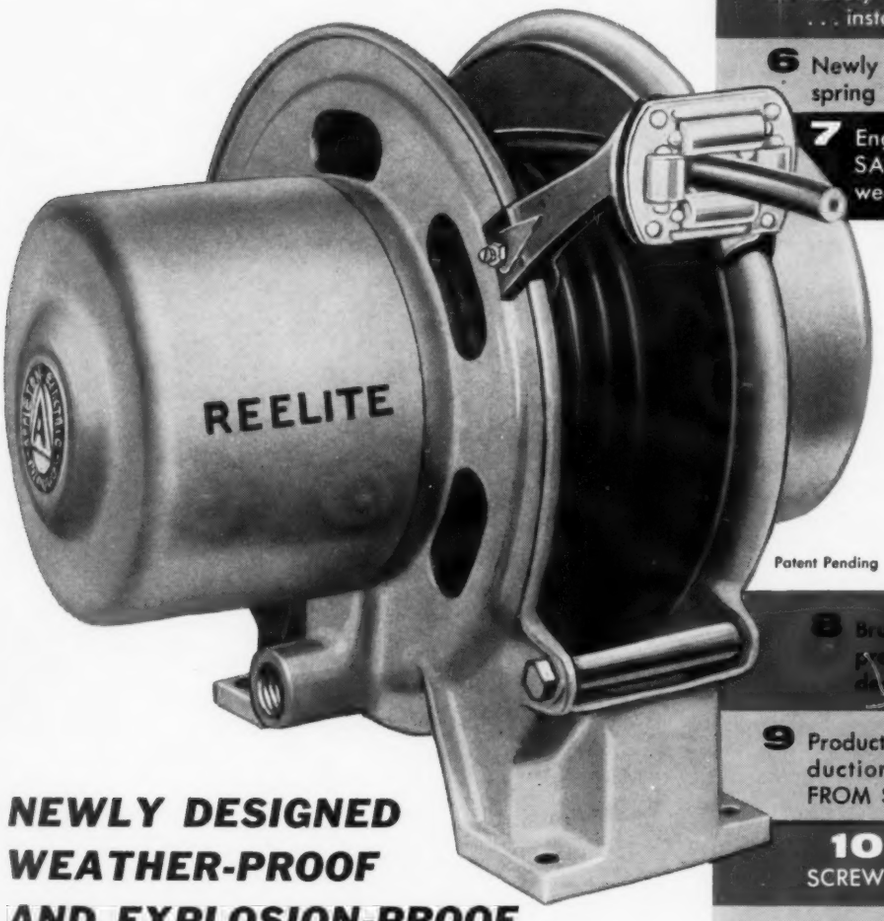
BALDWIN · LIMA · HAMILTON

Eddystone Division

Philadelphia 42, Pa.

Hydraulic turbines • Weldments • Dump cars • Nonferrous castings • Diesel engines • Special machinery • Bending rolls • Ship propellers

NEW from APPLETON®



1 Available in both WEATHER-PROOF and EXPLOSION-PROOF series.

2 One-piece UNI-CAST main frame . . . assures perfect alignment . . . lightweight.

3 Snap-on or threaded covers . . . NO SCREWS . . . remain tightly sealed . . . release in seconds.

4 HOLLOW SHAFT construction . . . pressure type internal cable grip . . . fast cable replacement.

5 Safety SPRING CARTRIDGE . . . self-contained . . . instantly replaceable.

6 Newly designed SPRING MOTORS . . . finest spring steel . . . longer life.

7 Engineered for easy installation . . . SAFE MAINTENANCE . . . under all weather conditions.

Every feature you want is here! . . . 15 reasons why APPLETON'S new Reelite Series gives you safe, uninterrupted service with considerable maintenance savings

Patent Pending

8 Brushes with floating tension . . . uniform pressure . . . ARC-LESS contact on newly designed collector rings.

9 Production line economies . . . volume production savings . . . immediate DELIVERY FROM STOCK.

10 No special tools required . . . only a SCREW DRIVER needed for maintenance.

11 MULTIPLE CONDUCTOR units available . . . wide, dependable electrical contact surfaces.

12 Wide range of ACCESSORIES . . . custom installations.

13 Internal RATCHET available. Will prevent recoil of cable, when application requires it. Specify if desired.

14 Explosion-proof models have pre-wired explosion-proof chamber from collector rings to junction box . . . designed for HAZARDOUS AREAS.

15 Custom assembly . . . constructed by experienced REELITE technicians.

Contact Your Nearest APPLETON Field Engineering Office for Further Application Information.

NEWLY DESIGNED WEATHER-PROOF AND EXPLOSION-PROOF

REELITES

automatic cable take-up reels

THE STANDARD FOR BETTER REELS

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Also Manufacturers of:

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HIGH-SPEED

CONTINUOUS PICKLING LINES

BATTERY OF FOUR MESTA HIGH-SPEED CONTINUOUS PICKLING LINES WITH TRIMMERS, UPCOILERS, AND MESTA-THOMSON FLASH WELDERS

MESTA-THOMSON FLASH WELDER INSTALLED IN A MESTA HIGH-SPEED CONTINUOUS PICKLING LINE

Designers and Builders of Complete Steel Plants

MESTA MACHINE COMPANY

PITTSBURGH, PENNSYLVANIA

Personnel News...

Robert B. Meneilly was named to the newly-created position of general manager—tin mill products for United States Steel Corp. In his new capacity, Mr. Meneilly will administer a co-ordinating service for the executive vice presidents—commercial, production and engineering and research. He formerly was manager—tin mill products, and has been succeeded in that position by **Donald K. Wright,** former assistant manager. Mr. Meneilly joined U. S. Steel in 1937 as assistant to the chief metallurgical engineer in Pittsburgh, Pa. Three years later he was named tinplate metallurgical engineer, and in 1952 was promoted to the position of assistant to manager—tinplate sales. He served as assistant manager—tinplate sales for two years before his appointment as manager—tin mill products in 1958. Mr. Wright joined U. S. Steel in 1939 as a market research analyst in Pittsburgh. He became a salesman in the Pittsburgh district office two years later, and served in the Philadelphia and Indianapolis district sales offices in various managerial capacities before returning to Pittsburgh as assistant manager—tin mill products in 1956.

Arthur W. Gittins, has been named division superintendent of primary production at Wheeling Steel Corp.'s Steubenville Works. Mr. Gittins was assistant superintendent of the Hanna Furnace Corp. in Buffalo, N. Y., before joining Wheeling Steel. Prior to that, he was associated with Jones & Laughlin Steel Corp. in Pittsburgh, Pa.

David P. Moore, Sr., has been appointed supervisor of quality control at the Louisville, Ohio, plant of Jones & Laughlin Steel Corp., Stainless and Strip Division. Mr. Moore, who formerly was service metallurgist, joined J&L in July, 1958, in that capacity. He previously was associated with Pittsburgh Steel Co., Hudson Motor Car Co., and Crucible Steel Co.

David W. McDowell, field metallurgist for Republic Steel Corp.'s Union Drawn Steel Division in the Chicago area, and a veteran of 31 years' service with the company, retired September 30. **James W. Hauger** succeeds Mr. McDowell as field metallurgist in Chicago, and **Louis F. Rosing, Jr.,** succeeds Mr. Hauger as plant metallurgist at Union Drawn's Gary, Ind., plant. Mr. McDowell joined Union Drawn in 1928 as plant metallurgist at Gary. He was appointed field metallurgist in Chicago in 1936. Mr. Hauger also started at the company's Gary plant in 1928. He was named plant metallurgist at Gary in 1949, after having been employed as assistant plant metallurgist, chemist and in various general laboratory and industrial engineering assignments. Mr. Rosing, who has been with Republic since 1944, has served as assistant plant metallurgist at Union Drawn's Massillon, Ohio, plant since January, 1958, after being metallurgist there since 1954. Prior to that time, he was employed in Republic's Cleveland Steel District and Central Alloy Steel District.

R. J. Bartholomy was appointed assistant superintendent of the Youngstown Sheet and Tube Co.'s Campbell Open Hearth Department. A turn foreman since 1956, Mr. Bartholomy has been with Sheet and Tube since 1924 when he was hired as a brakeman in the open hearths at Campbell. He worked as third helper, second helper, first helper, melter and senior helper before being made turn foreman.

Walter J. Prochak has been named superintendent of the Cold Drawn Bar Department of the Youngstown Sheet and Tube Co.'s Brier Hill plant. He succeeds **Floyd Hoskinson** who retired September 1 after 10 years in the position. Mr. Prochak has been assistant superintendent since 1953. He joined the company in 1947 and in 1950 became a metallurgist at Brier Hill. Mr. Hoskinson, before joining the Youngstown Sheet and Tube Co. in 1949, had previously held responsible operating posts with Copperweld Steel Co. in Warren, a subsidiary of Republic Steel in Buffalo, N. Y., U. S. Steel in Canton, Ohio, and Union Drawn Steel Co. in Beaver Falls, Pa.

Maurice J. Day, former vice president—technology, Crucible Steel Co. of America, was named to the newly created post of vice president—commercial. **Walter E. Gregg** succeeds Mr. Day as head of the Technology Department with the title of director of technology. He

R. B. MENEILLY

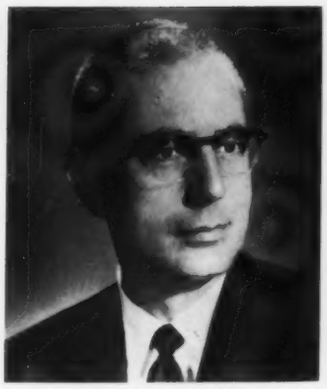
D. K. WRIGHT

A. W. GITTINS

D. P. MOORE, SR.

JOSEPH MOLNAR

C. C. WOMACK



J. N. HUTSON

F. W. CHAMBERS

also continues in his present position as director—technical development division.

Joseph Molnar was named chief industrial engineer—methods, United States Steel Corp. At the same time **C. C. Womack** succeeds Mr. Molnar as chief industrial engineer—wage and salary evaluation. Mr. Molnar joined the National Tube Division of U. S. Steel in 1933, transferring to the American Steel & Wire Division in 1941. There he served first as division industrial engineer at the Cleveland, Ohio, Cuyahoga Works, and then as staff industrial engineer and supervisor. In 1951, Mr. Molnar was transferred to the central office in Pittsburgh as chief industrial engineer—wage and salary evaluation, the position he held at the time of his present appointment. Mr. Womack joined U. S. Steel in 1936 as an industrial engineer at Duquesne Works. Following a series of promotions and transfers to various plants in the Pittsburgh area, he was appointed plant industrial engineer at the Youngstown, Ohio, district works, and in 1952 became assistant to the general superintendent, the position he held until his present appointment.

John N. Hutson has been named district manager of Federal Pacific Electric Co.'s newly established Birmingham, Ala., district sales office. Mr. Hutson was previously Birmingham district manager for Square D Co. He is currently serving as secretary for the Birmingham District Section of AISE.

Frank W. Chambers was appointed executive vice-president of Strategic Materials Corp. Mr. Chambers has been director of engineering of the Kennecott Copper Corp. since 1951. Prior to his association with Kennecott he was manager of the Production, Engineering and Construction Division of Koppers Co., Inc.

John A. Succop, vice president in charge of metallurgy for Heppenstall Co., has retired after 39 years service with the company. He will continue to serve the company in a consulting capacity. Starting in the heat treat department of Heppenstall, Mr. Succop was transferred to the metallurgical department in 1921. He was appointed chief metallurgical engineer in 1944 and was elected a vice president in 1956.

J. Paul Tierney has been appointed superintendent of the rod, wire and conduit departments at Youngstown Sheet and Tube Co.'s Campbell Works. He previously was assistant superintendent and succeeds **Joseph Williams,** who died last June. Mr. Tierney worked briefly for Sheet and Tube in the late 1920's and returned in 1934 as an assistant tester in the rod and wire metallurgical department. In 1940, he became an assistant metallurgist and in 1944 was named metallurgist in the rod, wire and merchant mills. He was made assistant superintendent of rod, wire and conduit operations in 1953.

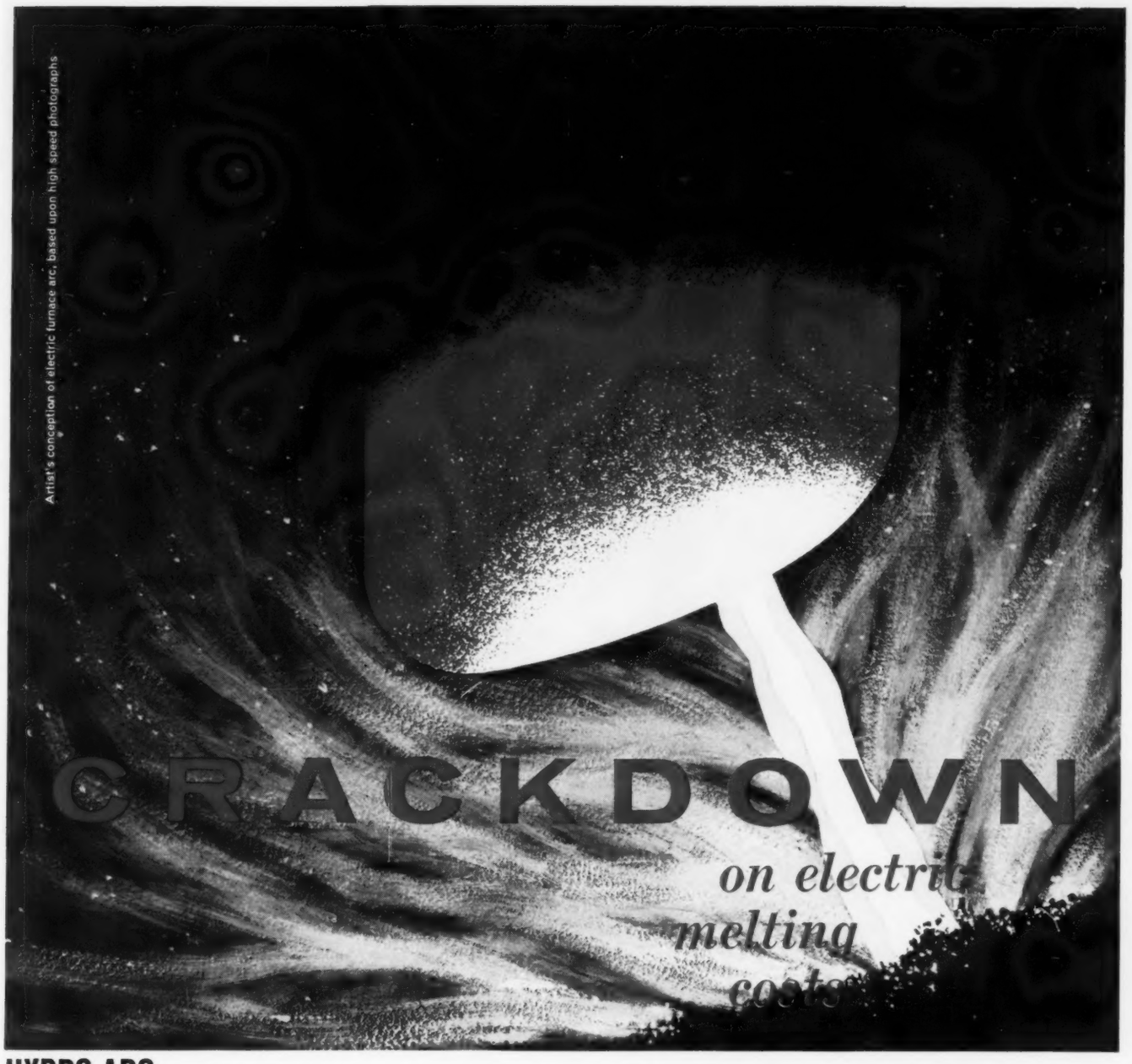
William J. Pohl, Jr., has been appointed administrative assistant to the director, production planning programs for Jones & Laughlin Steel Corp. Mr. Pohl formerly was assistant superintendent, Production Planning Department at J&L's Aliquippa Works. He has been a J&L employee at the Aliquippa Works since 1933. He started as a bill clerk in the Rod and Wire Department, and since has held positions in the office of the works manager, Order and Shipping Department, and in the Tin Plate Department. He was named assistant superintendent of the Production Planning Department in 1954.

Glenn M. McComb has been added to the staff of Production Machinery Corp. as sales engineer. Mr. McComb has been active since 1949 in the engineering and sales of equipment for processing steel and other metals.

Ross Russell has been named manager of Industrial engineering at the Timken Roller Bearing Co. Mr. Russell's duties will be to co-ordinate and direct the industrial engineering activities of the company. Mr. Russell started with Timken in 1942. In 1950 he was named a senior industrial engineer. He was named division industrial engineer of the Steel and Tube

ROSS RUSSELL

TARZAN MONDA



HYDRO-ARC electric furnaces keep arcs burning at peak intensity every moment—and turn extra wattage into melt. The key: instantaneous electrode movement, monitored by the very *energy* of the arc itself.

Air counterbalanced electrodes and a unique dual motor hydraulic control circuit virtually eliminate troublesome inertia or mechanical lag. When turbulance in the metal charge effects arc gap, electrode reaction is immediate—readjustment is exact! Here is electric melting efficiency you may not have thought possible . . . cost reductions that open many new applications for fast, clean, economical electric melting. Hydro-Arc may put a fresh light on your own plans for additional melting, smelting, or other heating facilities.

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A New Kind of D-c. Motor With DYNAMIC RESPONSE

Here is a motor built to make maximum use of d-c. flexibility. The Super 'T' puts Dynamic Response into starts, stops, and speed changes. Dynamic Response gives you a 50% increase in torque and a 50% decrease in reaction time.

This top performance is due to advanced, balanced design. Lighter small diameter armatures cut mechanical inertia 50%. Superior Class B insulation, gives extended life even at temperatures as great as 130°C.

Top grade insulation plus engineered ventilation lets the Super 'T' take tremendous overloads. In fact, the Super 'T' can develop double normal horsepower during starts, stops, and speed changes.

The Super 'T' is a compact power package, designed inside and out for tough industrial service. From appearance to performance, the Reliance Super 'T' with Dynamic Response is today's most modern industrial motor.

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Sales Offices and Distributors in Principal Cities

Division in 1955, the position he held until his recent appointment. Succeeding Mr. Russell as division industrial engineer of the Steel and Tube Division is **Tarzan Monda.** Mr. Monda joined the Industrial Engineering Department in 1946 and in 1951 was named senior industrial engineer, the position he held until his recent appointment.

L. J. Frick was named manager, general industrial sales, and **J. S. Quinn** manager, heavy industry sales, St. Louis, Mo., district, Allis-Chalmers Manufacturing Co., Industries Group. Mr. Frick has been with Allis-Chalmers since 1942, the last 13 years a sales representative in the St. Louis district. Mr. Quinn joined Allis-Chalmers in 1949 and became a sales representative in the St. Louis district in 1951.

E. C. Bolton has been named as Cutler-Hammer Inc., midwestern regional sales manager. Mr. Bolton has been on the Cutler-Hammer engineering and sales staffs since 1922. Prior to his regional sales appointment, he had managed the company's district sales office in Cincinnati, Ohio. Replacing Mr. Bolton in Cincinnati is **J. H. Sauer,** formerly manager of Cutler-Hammer's Indianapolis, Ind., district. **R. A. Pancoast** of the Philadelphia, Pa., sales staff has been elevated to the post of Indianapolis manager.

Donald J. Wolfe has been named manager of sales development for Southwestern Engineering Co.'s Krupp-Renn and Lurgi processes. His prior associations were with United States Steel Corp., Youngstown Sheet and Tube Co., and Inland Steel Co.

Harry W. McLaughlin, Jr., has been named secretary and assistant to the president of American Forge and Manufacturing Co. Associated with the company since 1952 as a salesman and as general manager since 1957, Mr. McLaughlin was formerly affiliated with United Engineering and Foundry Co. in Pittsburgh for 10 years.

Russell A. Hedden has been appointed works manager of manufacturing, Industries Group, at Allis-Chalmers Manufacturing Co.'s West Allis Wis., Works. He succeeds **E. W. Bonness** who has been named consultant to the director of manufacturing, Industries Group. Mr. Hedden formerly was works manager of the company's York, Pa., Works, a position he held since 1957. He joined the S. Morgan Smith Co. (now the York Works of Allis-Chalmers) in 1951 as comptroller.

Robert E. Lenhart has been appointed supervisor of silicon steels in Crucible Steel Co.'s central research laboratory. He was formerly manager of alloy development at the Beryllium Corp.

Edgar L. Bands has been appointed superintendent of the hot strip mill of the Ashland Works of Armco Steel Corp. At the same time **William T. Watson** was named superintendent—shipping. Mr. Bands succeeds **W. Fred Songer,** who has retired. Prior to his recent appointment, Mr. Bands was assistant superintendent of the Ashland Works hot strip mill. He joined Armco at Ashland in 1926. Mr. Watson joined Armco's Ash-

(*Please turn to page 212*)

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Keep lube oil clean... free from mill scale and other ferrous grit

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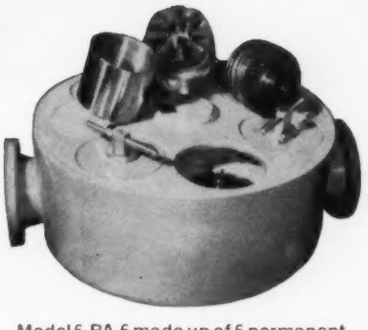
Magnetic Separators

help reduce gear and bearing wear as well as costly maintenance by extracting even the finest of ferrous particles that bridge the oil film and cause metal-to-metal contact. Sizes range from ⅜" to 8" pipe connections.



Model 6-PA-6 made up of 6 permanent magnet separator assemblies for 8" pipe line.

High Pressure **FERROFILTERS** also available for Hydraulic Systems up to 5000 psi.

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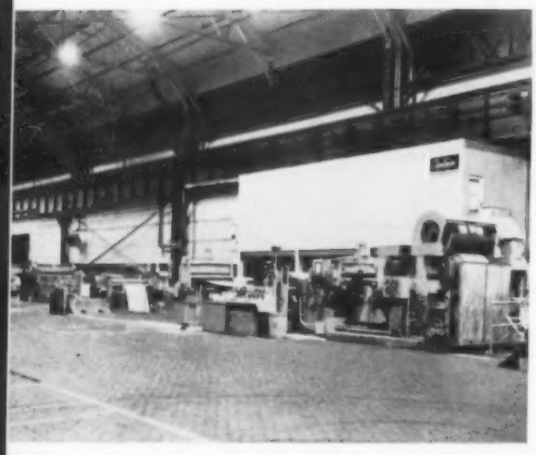
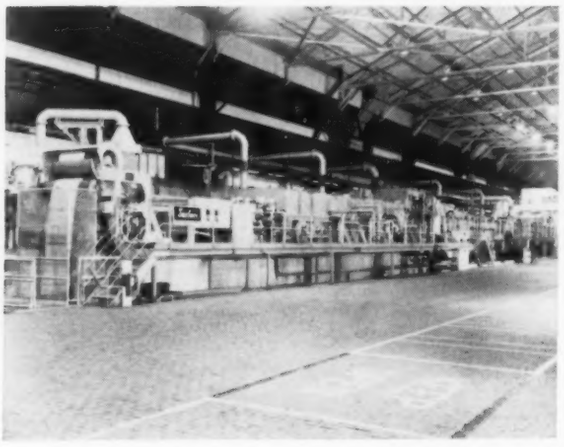
complete normalizing line:

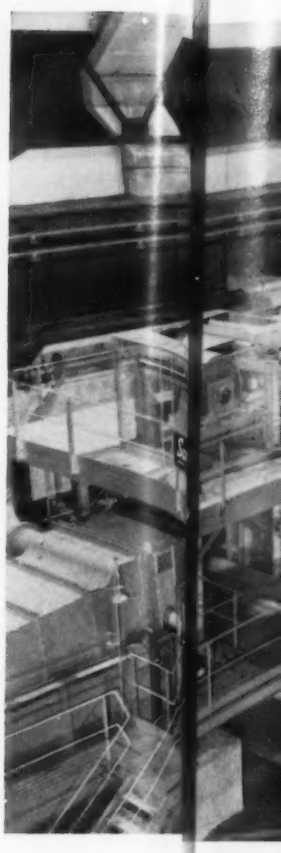
ALL SURFACE!

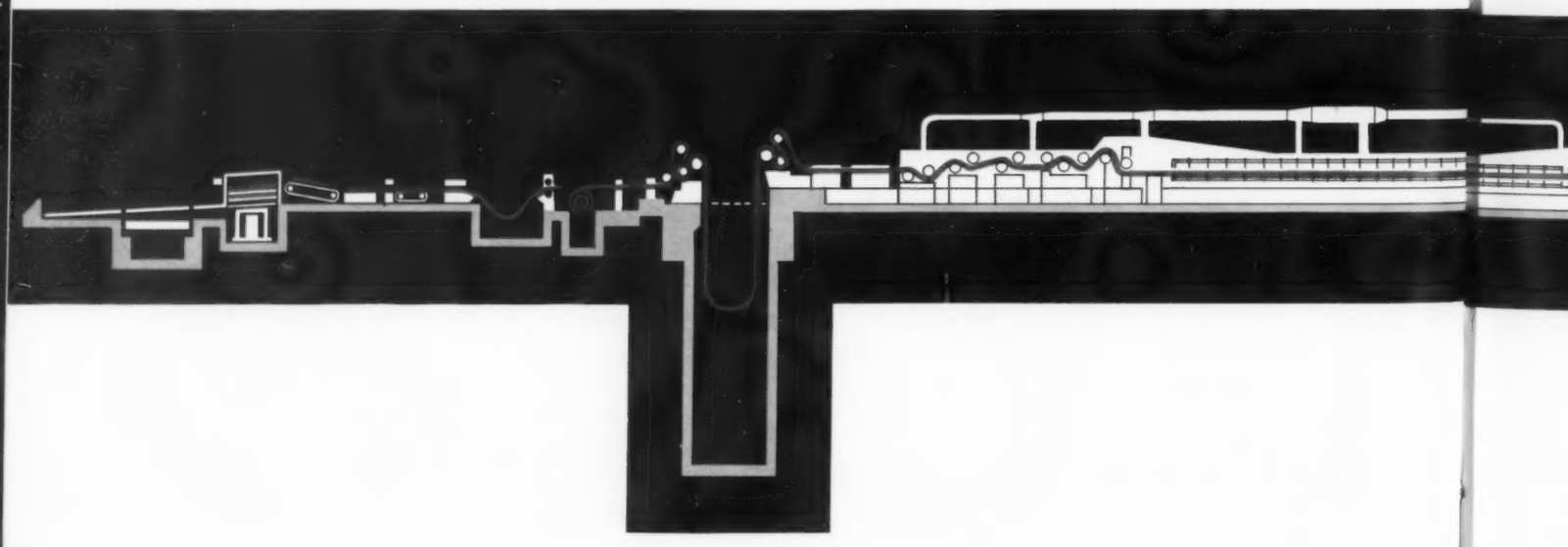


Exit end of the line, showing looping pit, "re-coiler," automatic shear and sheared sheet piler.



Pickling section includes acid bath, water rinse tank, brush scrubbers, alkali tank and dryer, all installed by Surface. This view shows the exit end of the section.





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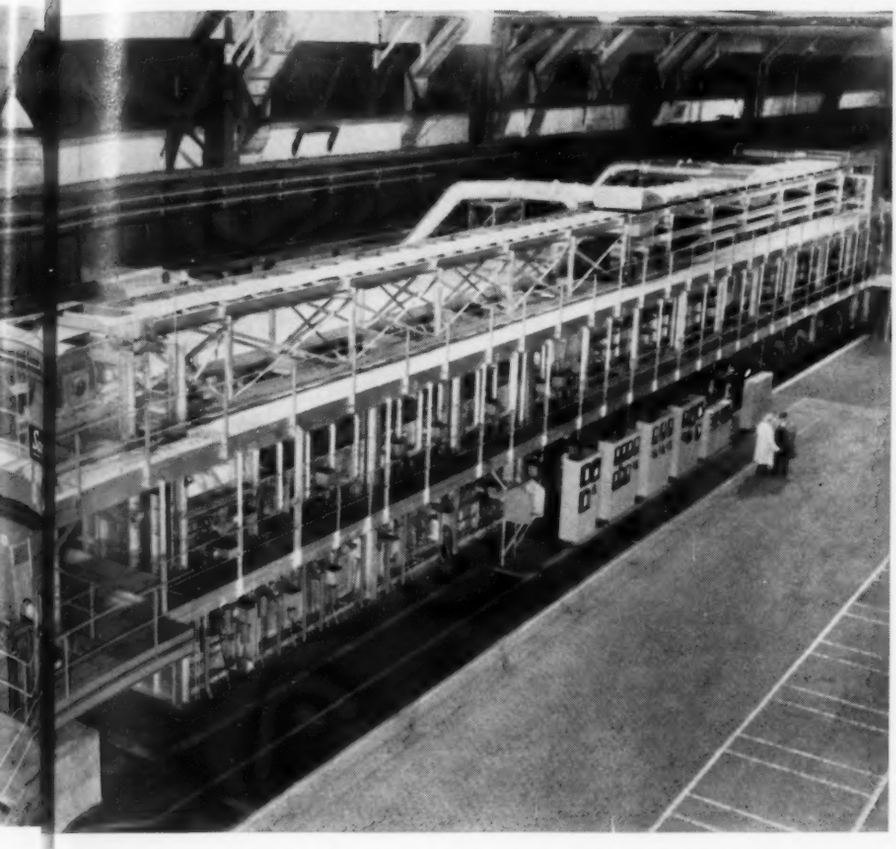
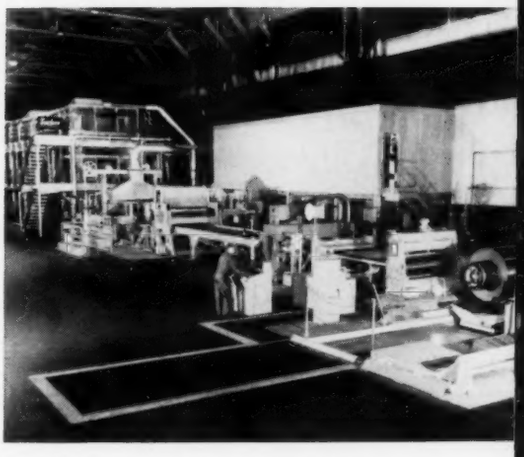
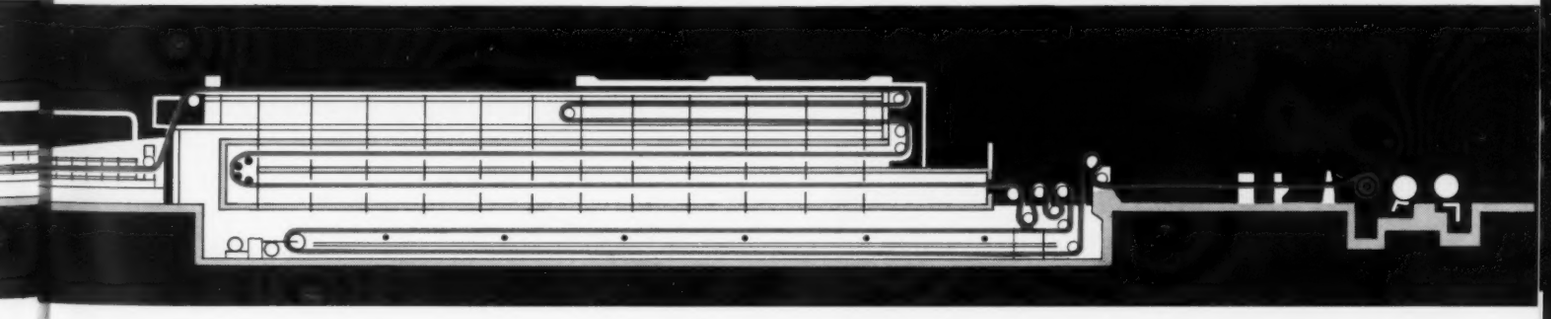
Worldwide engineering and manufacturing facilities through associates in Australia • Belgium • France • Germany • Great Britain • Italy • Japan



Rockwells in the low 40's are achieved consistently in this three-level normalizing furnace. Heating zone is on the lower furnace level; convection cooling in the middle; air blast cooling at the top. A horizontal "looper" is located underneath the furnace.



Payoff reel marks the entry of low carbon stock after cold rolling. Speeds of 150 fpm on 60" wide strip are attained.



This complete new Surface normalizing line for vitreous enamel stock started paying off on its first day of operation. For example, its capacity of 30,000 lbs. an hour puts this mill forcefully into the market for deep draw quality strip. More than adding new selling power, this big line increased productivity per operator by an almost unbelievable amount.

From payoff reel to real payoff, the entire installation is a graphic demonstration of Surface's qualifications as prime contractor. Applying its global experience in metallurgy, combustion, chemistry, and mechanization, Surface engineered and installed the complete line.

Take the opportunity now to evaluate the prime contracting skills available at Surface, and mobilize them for your profit, ***wherever heat is used in industry.***

Surface

SURFACE COMBUSTION CORPORATION *2404 Dorr Street, Toledo 1, Ohio*

O. D. RICE

F. A. BLAINE

J. G. SOLARI

H. W. RAINEY, JR.

(*Continued from page 209*)

land Works in 1951. He worked in the metallurgical department and zinc-coating operations until April of this year when he was named assistant superintendent—shipping.

O. D. Rice has been elected president of Rust Furnace Co. A founding member of the 30-year-old company, Mr. Rice has served as general manager, vice president and director. **Frank A. Blaine,** formerly assistant general manager of Rust Furnace Co., has been made general manager, succeeding Mr. Rice. Mr. Blaine has been with Rust since 1946 and has served as field engineer, construction superintendent and project manager.

Joseph G. Solari has been appointed vice president in charge of sales for Great Lakes Carbon Corp.'s Carbon Division. Prior to joining Great Lakes Carbon, Mr. Solari had been vice president and a director of Sterling Precision Corp.

H. W. Rainey, Jr., has been appointed general sales manager of the Sturtevant Division of Westinghouse Electric Corp. Immediately prior to his new appointment, Mr. Rainey held the position of field sales manager for three years.

E. L. Talley, Jr., was appointed manager of sales, mechanical products, Salem-Brosius Inc. Mr. Talley had been administrative assistant to the vice president of sales. His new duties will include direction of sales efforts of the forge shop and mill mechanical equipment and the general line of materials handling products built at the company's Carnegie, Pa., plant.

William E. (Buck) Lynch has been appointed superintendent of the blooming mill at the Crucible Steel Co.'s Midland Works. He replaces **O. N. Carter** who retired.

John F. O'Hear, formerly of Fairless Works, United States Steel Corp., has been made superintendent of plant maintenance for Sociedad Mixta Siderurgia Argentina (Somisa) in San Nicolas, Argentina. An integrated plant for the Argentine government is under construction on the Parana River.

J. M. Duncan has been appointed manager, Industries Group Sales of Allis-Chalmers Manufacturing Co.'s Washington, office, and **B. G. Camp,** manager of the Atlanta, Ga., district. Mr. Duncan, who had been manager of the Atlanta district since 1956, succeeds **W. P. Bell,** recently named sales manager, small, medium and marine units, Steam Turbine Department.

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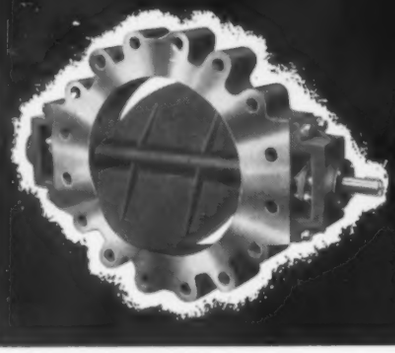
SERVE YOU?



The application of Fisher-Continental Butterfly Valves is virtually limitless in the gas, vapor, liquid or semi-solid flow control industries. These compact, low cost controls fit the specifications of a vast majority of applications.

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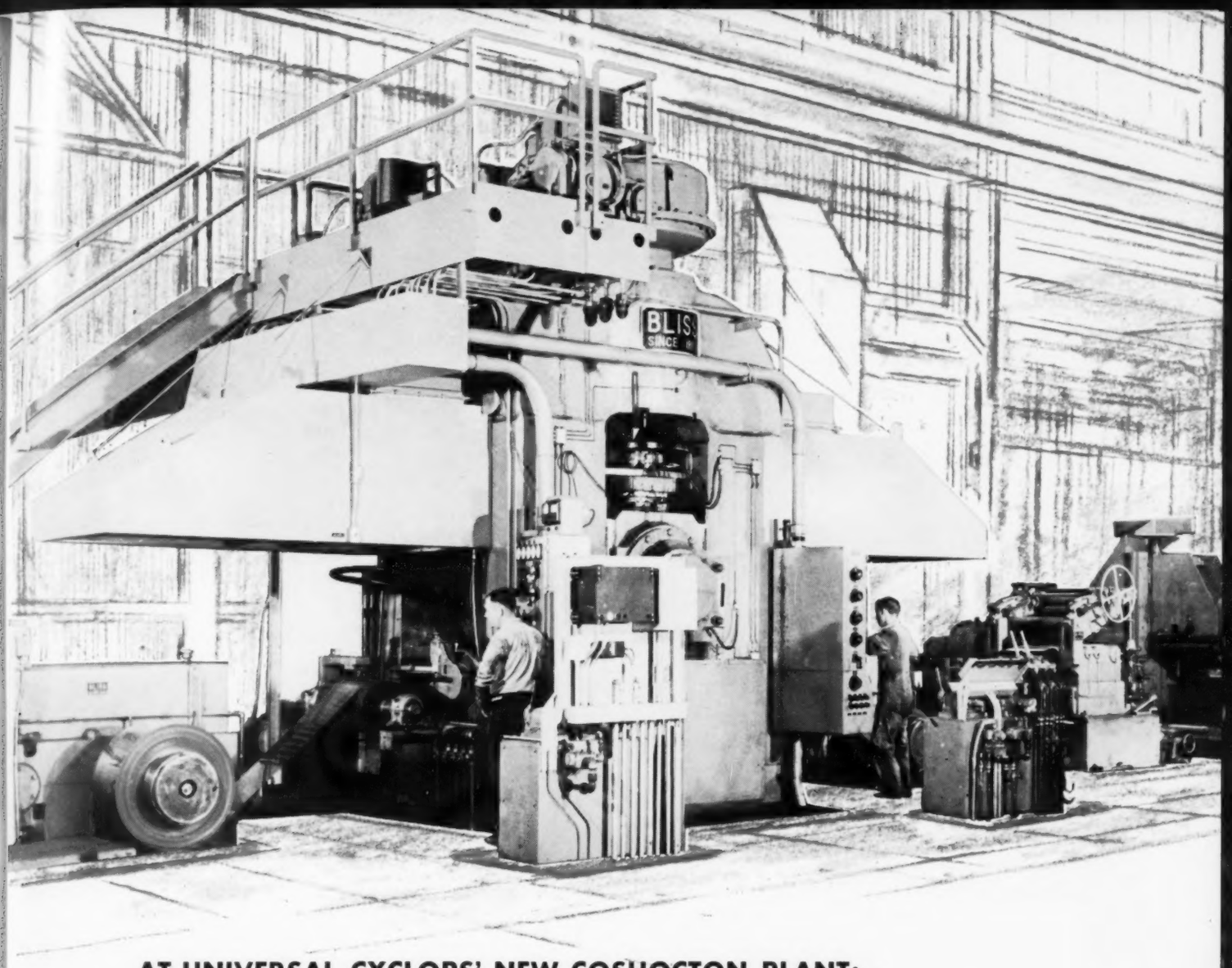
Obituaries

Walter F. Munford, president of United States Steel Corp., died September 28. He was 59. Mr. Munford had been president and chief administrative officer of U. S. Steel, a member of its board of directors and chairman of its executive committee since May 5 of this year. Until his election as president, Mr. Munford had been executive vice president—engineering and research. For two years prior to that, he was assistant executive vice president of the corporation and, from 1953 to 1956, was president of U. S. Steel's American Steel and Wire Division.



AT UNIVERSAL-CYCLOPS' NEW COSHOCTON PLANT:

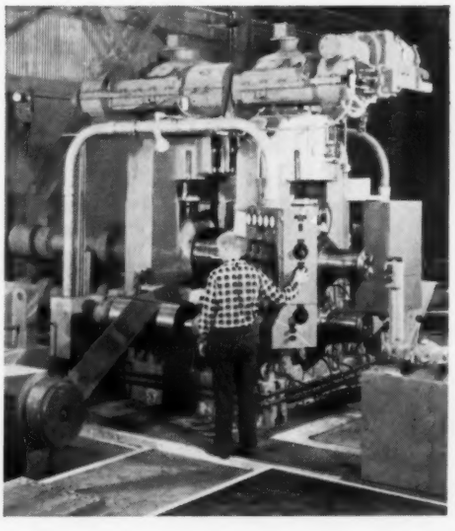
Stainless gets a fine finish fast

All the rolling at Universal-Cyclops Steel Corporation's new stainless strip finishing plant at Coshocton, Ohio, is accomplished on two rolling mills designed and built by Bliss' Rolling Mill Division. Steels rolled include all standard AISI grades in widths up to 24 inches.

Workhorse of the two mills is the 4-high reversing mill shown above. It is ruggedly built to stand heavy rolling stresses developed at speeds as high as 1000 fpm. Auxiliary equipment includes a three-stop coil entry ramp, coil buggy and mandrel-type payoff reel, flattener and feed roll, tension reels and coil buggies.

The two-high Bliss temper mill (right) is used principally for straight chromium grades of stainless providing proper hardness and a lustrous finish to the strip. An unusual design feature is the absence of an entry guide box, eliminating a source of dirt accumulation and strip scratching.

These two mills at Universal-Cyclops are typical of the modern approach to rolling mill design you'll find at Bliss. For other examples of our work, write us today for your complimentary copy of the 84-page Bliss Rolling Mill Brochure, Bulletin 40-B.



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Bliss is more than a name . . . it's a guarantee

E. W. BLISS COMPANY, Rolling Mill Division, Salem, Ohio

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Anything that can be operated from the floor can also be operated *from the crane* with a Femco Remote Control System.

Your cranemen can operate soaking pit covers, open and close furnace doors, position ingot buggies, start and stop conveyor belts, operate upenders. Trippers and hoppers can be operated from ore bridges, cover cranes controlled from an overhead crane, or one overhead crane controlled from another crane.

Hundreds of Femco systems are now in service, performing these and other tasks for steel mills throughout the country, enabling these mills to save time and reduce costs.

These systems require no special wiring—they utilize carrier frequencies transmitted over existing power circuits. They are rugged and dependable, designed and built for the severe conditions of steel mill service. Components plug in for easy replacement . . . any maintenance that may be necessary can be handled by your regular maintenance crews.

We will be glad to discuss the applications of Femco systems in your plant. Just write to Femco, Inc., Irwin, Pa. VMA 6792

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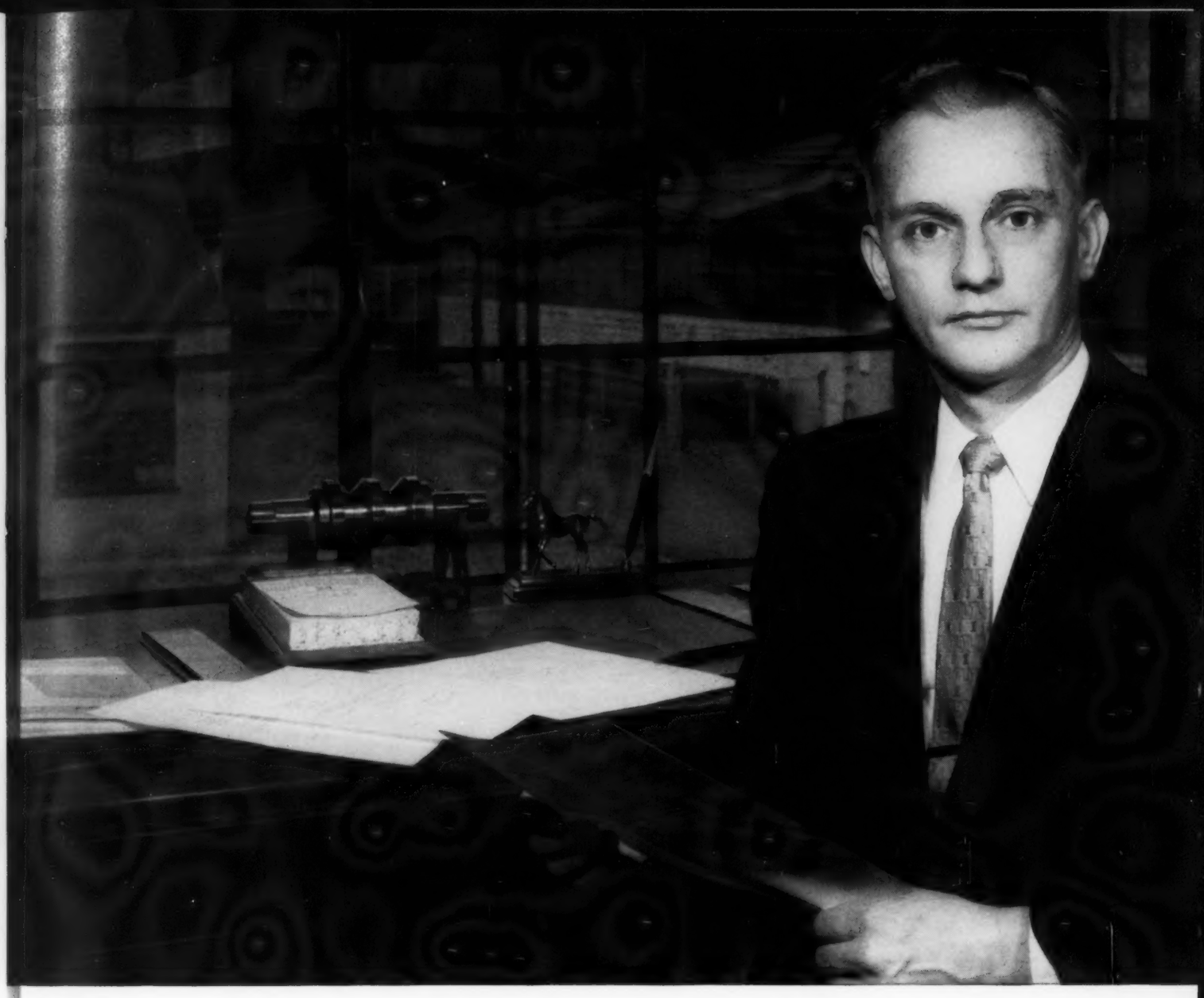
COMMUNICATIONS: Carrier and wired audio systems for all mining and industrial applications. **MONITORING:** Fans, circuit breakers, valves, pumps, compressors, etc. **TELEMETERING:** Flows, pressures and other functions. **REMOTE CONTROL:** Pumps, valves, circuit breakers; soaking pit covers, furnace doors; cranes, or other moving equipment.



"Looking for a dependable source for steel rolls? Call National,"

says Bill Mason, Assistant to Manager—Roll Sales.

"When you call, let me tell you about our complete customer service and our expanded facilities for producing steel rolls . . . plain or grooved, in all grades. Many of our facilities are new, from the steel foundry building itself to the melting and heat treating furnaces, and precision machining equipment.

"Also, you can be sure that from the time your order reaches us it will get the individual attention given every roll order at National from careful checking of specifications and skillful manufacture to follow-through in the field by experienced representatives.

"We believe this special attention is reflected in the outstanding performance of National rolls in our customers' stands. You will be pleased with their performance in *your* stands.

"Call National for your steel roll requirements."

GENERAL STEEL CASTINGS

National Roll & Foundry Division

Avonmore (Westmoreland County) Pennsylvania

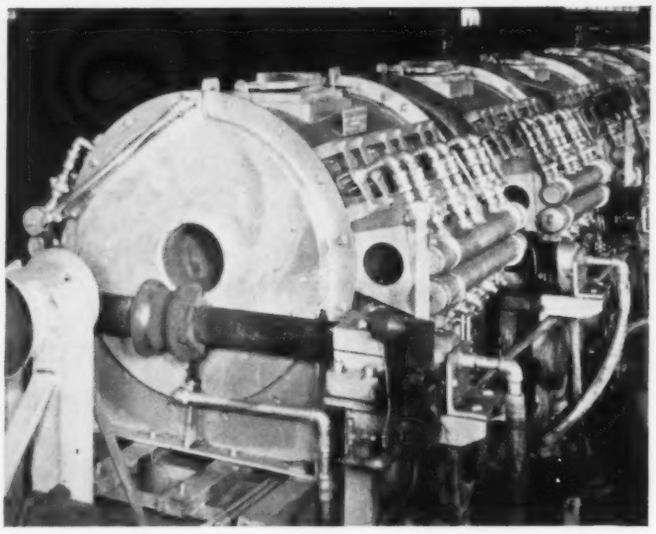
General Steel Castings Corporation: General Offices, Granite City, Ill.

Plants: Granite City, Ill.—Eddystone, Pa.—Avonmore, Pa.

Electrode ports of this electric furnace roof are formed of B&W castable. B&W Kaocast or Kaocrete-32 can be successfully used, depending on severity of service.

High thermal release burner block is cast of B&W Kaocrete-32. Both Kaocrete-32 and Kaocast are used for burner blocks and other services in many other furnaces.

Nose arch of walking beam type furnace for heating forgings is made of Kaocast, B&W's 3000 degree castable. Kaocast is also used in forming complete forging furnaces.



This high speed barrel type heating furnace is typical of many which are completely lined with high temperature B&W Kaocast.

How B&W refractory castables solve high temperature problems

The higher temperatures in industrial processes have called for refractory castables that will stand up in these severe services. B&W offers two extremely durable, high temperature refractory products—Kaocrete-32 for applications up to 3200 F, and Kaocast with a 3000 F use limit. Both have high strength, unusual volume stability and excellent resistance to spalling and slag attack. Investigate B&W *specialized* refractory castables for solutions to your high temperature problems.

B&W Bulletin R-35A gives additional information on versatile B&W refractory castables. Write for copy to The Babcock & Wilcox Company, 161 East 42nd Street, New York 17, N.Y.

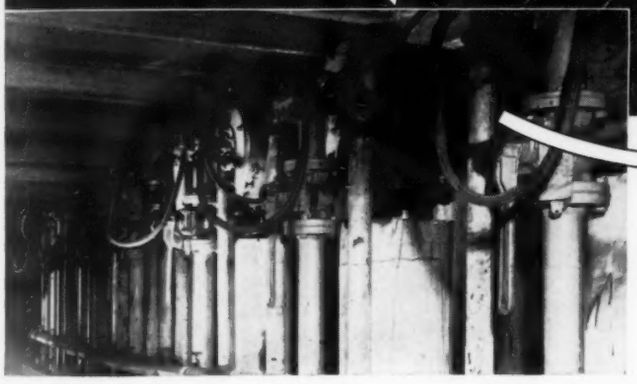
R620R

B&W THE BABCOCK & WILCOX COMPANY

REFRACTORIES DIVISION

B&W Firebrick, Insulating Firebrick, and Refractory Castables, Plastics, Ramming Mixes, Mortars, and Ceramic Fiber.

ARMCO uses North American
Refractory-Lined Dual-Fuel Burners



Four new Salem-Brosius slab heaters in Armco Steel Corporation's Middletown Works Hot Strip Mill are fired with North American Series 6819 Burners with internal mixing oil atomizers and Sensitrol Valves. Air is preheated to 700 F. Fuel is natural gas or #6 oil.

The top bank of each furnace has eight 10" burners and two 8" burners firing in the direction of work travel; bottom bank has five 10" burners and two 8" burners firing in the opposite direction. Each 10" burner releases 5,200,000 Btu/hr with 700 F air at 2" wc; each 8" burner releases 3,600,000 Btu/hr.

Furnaces are 27' wide x 34' long inside, and are designed for 125 tons of hot slabs per hour.

Here's Why You Should Too:

1. **Low maintenance**—quality alloy and refractory materials—metal parts not exposed to furnace radiation—designed for 1200 F preheated air.
2. **Easy accessibility**—quick disconnect atomizer—all parts removable from back.
3. **Retractable oil atomizer**—can be pulled back quickly and easily for gas firing.
4. **Gas and air openings proportional** for all sizes; so a variety of burner sizes can be used on the same manifold.
5. **Long or short flame** models available.
6. **Internal or external mixing atomizers** available.
7. **Low first cost**—plus North American's reputation for good service—in engineering and on the job site.

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Call your nearby North American engineer or write for DF 6819

The North American Mfg. Co.
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Now iron producers can cut copper costs with new "Customized Conductivity"

This revolutionary new concept is the result of NBD's combined simulated-service and actual blast furnace tests begun in 1957. Gives iron producers the first practical answer to lowest possible copper costs per ton of iron produced.

Tests proved that *high-conductivity copper lasts longer* . . . and for greatest economy in furnace operation, the majority of iron producers should use at least 70% conductivity! However, some installations can get significant savings from higher conductivity—even above 90%. Others may operate profitably at levels as low as 50%, sacrificing the advantages of high thermal efficiency for higher abrasion resistance that may be necessary for specific operating conditions.

The point is this: high conductivity pays off—but only when you pay for the *exact* conductivity *you* need.

Now NBD offers you the experience, skill and facilities needed to produce just the right copper for your furnace—the highest practical conductivity—conductivity that yields maximum operating economy. Our "Customized Conductivity" concept:

- Analyzes *your* copper requirements.
- Recommends the precise conductivity level your installation requires.
- Guarantees you the conductivity level you order.
- Assures you of prompt delivery of highest quality furnace copper.

Put NBD's "Customized Conductivity" to work for you next time you buy blast furnace copper. Call us about it.

AMERICAN Brake Shoe COMPANY

NATIONAL BEARING DIVISION
717-F Grant Building, Pittsburgh 19, Pennsylvania
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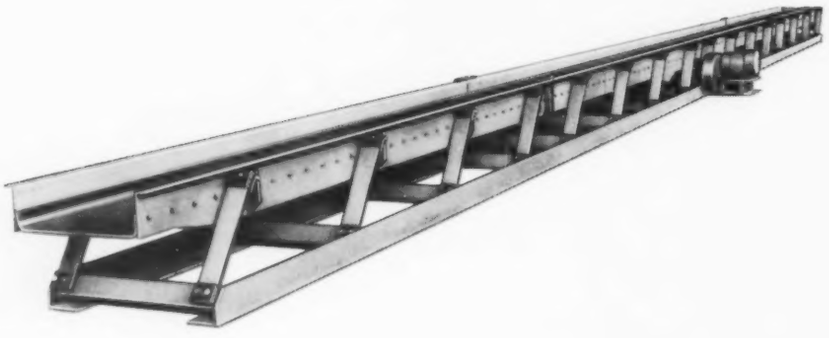
◀ This NBD instrument measures thermal conductivity of a copper tuyere, using eddy currents and radio waves. It is used on test plugs at the furnace, and again on finished castings.

SYNTRON

MECHANICAL VIBRATING CONVEYORS



lower bulk material handling cost

SYNTRON Mechanical Vibrating Conveyors are multi-purpose units designed for high speed conveying of bulk materials—with modifications their uses are virtually unlimited. They can be used as single units—multiple sections in tandem—combination screen and conveyor for scalping, sizing, dewatering and with heated troughs for drying, preheating, etc.

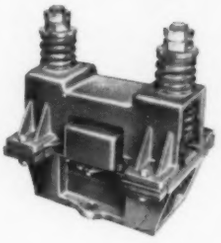
Each unit consists of two equal length troughs independently mounted on a common base. Motor driven eccentric and drive rod operates each section providing a powerful vibrating action that moves large volumes of material in a uniform, continuous flow.

SYNTRON Mechanical Vibrating Conveyors are available in lengths to meet most requirements. They are easy to install and operate.

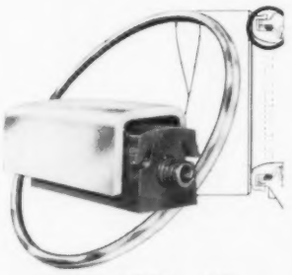
Low operating and maintenance expenses keep material handling cost down.

Write for free catalog data

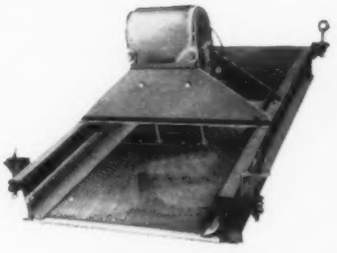
Other SYNTRON Equipment of proven dependable Quality



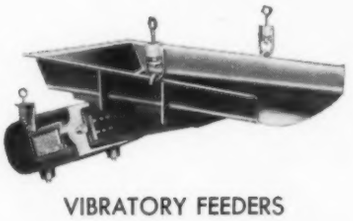
BIN VIBRATORS



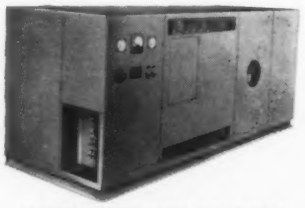
ROLL NECK AND MECHANICAL SHAFT SEALS



VIBRATING SCREENS



VIBRATORY FEEDERS



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FOR EVERY APPLICATION, THERE'S ONE CRANE OUTSTANDING...

IN PIPE MILLS: One of many P&H overhead cranes installed throughout the mill area, this P&H double-hook crane provides cat-quick but kitten-gentle handling of long and awkward loads of pipe. The twin-lift arrangement is typical of the complete attention P&H engineers give to custom-building cranes to your exact requirements. This means maximum crane efficiency with minimum operating costs because *your* crane is tailored for *your* job.

If you'd like more reasons why satisfied customers have made P&H the largest manufacturer of overhead cranes in the world, write for your free, information-packed copy of Bulletin C-42 to Dept. 111, Harnischfeger Corp., Milwaukee 46, Wisconsin.

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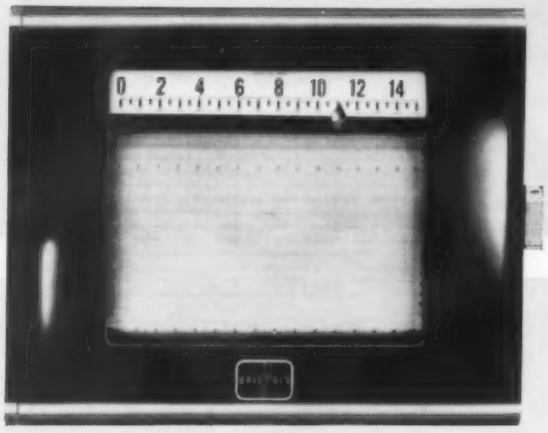
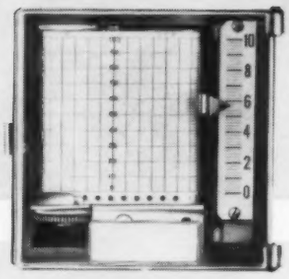
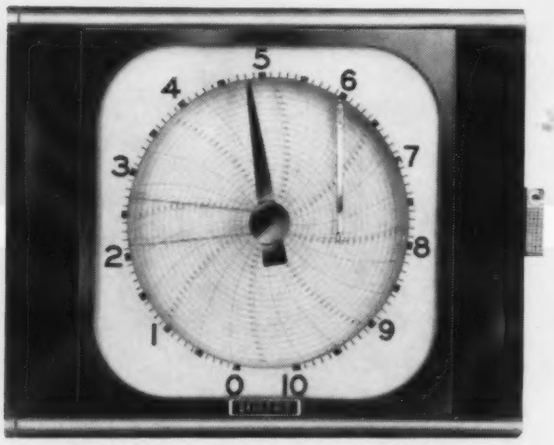


Dynamaster Electronic Potentiometer Pyrometer—Strip-chart model records on chart 11" wide, 120' long.



Miniature Electronic Dynamaster Pyrometer—Records on 3" strip-chart. Indicator model features easy-to-read 9" scale length.

Bristol Millivoltmeter Pyrometers—Free Vane* pyrometer controllers (shown) or indicating types. Many control modes available.



Dynamaster Electronic Potentiometer Pyrometer—Round-chart model records on 12" chart, indicates on extra large scale.

MODERN PYROMETERS...key to profitable use of HEAT

Bristol recording and automatic controlling pyrometers for temperatures up to 5000°F can help you increase product uniformity, cut fuel and maintenance costs

Bristol makes a wide range of pyrometers for every requirement: Electronic potentiometers, millivoltmeter and radiation types . . . for furnaces, ovens . . . every type of heating equipment, every kind of fuel. The reliability and accuracy of these precision instruments have been proved in thousands of installations.

Take just one advanced Bristol instrument, for example, the Electronic Dynamaster* Potentiometer Pyrometer:

CONTINUOUS STANDARDIZATION PLUS ACCURACY OF STANDARD CELL

Continuous standardization in Dynamaster Electronic Pyrometers requires no dry-cells, **but still retains the precision standard cell for highest stability and accuracy of voltage reference.** Results: No interruption to operation, no batteries to change. And here are just a few of the Dynamaster types available:

A model for every requirement: Dynamaster Pyrometers are available as single-pen, two-pen, and multiple-record (up to 24 points) *strip-chart* instruments and as *round-chart* instruments.

Electric and pneumatic controllers: Both strip- and round-chart instruments are made in a very wide variety of controllers that meet every furnace and oven control requirement, including the following in a great many forms:

Electric Control—on-off, proportional input, 3-position, proportioning, proportional with automatic reset, and time-program.

Pneumatic Control—on-off, proportional, and proportional with reset.

Miniature Dynamaster Pyrometer: Full plug-in flexibility . . . takes only 5" x 5⅛" of panel space, but has same basic accuracy, same time-tested operating principle as full-size Dynamaster pyrometers described above. Ideal for graphic panels and centralized recording or indicating of large numbers of variables. Either electrical or pneumatic control types available.

Write for complete data on Bristol Pyrometers—and remember Bristol offers a complete line of thermocouples and pyrometer accessories. The Bristol Company, 123 Bristol Road, Waterbury 20, Conn. *T.M. Reg. U.S. Pat. Off. D-D

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AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

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Note: Post cards expire three months after publication date.

(1) Automation Guidebook

An informative guidebook to automation through modernization is available from General Electric Co. The publication explains General Electric's concept of progressive automation, describes the tools of automation and tells how those interested in rolling and processing metal should plan for automation. The booklet also provides a detailed breakdown of automation potential in reversing hot mills, hot strip mills, processing lines and specialized processes.

(2) Cutting Fluids

A comprehensive review of factors involved in selecting cutting fluids has been published by Gulf Oil Corp. The book discusses such topics as the development of cutting fluids, machining properties of various metallic materials, internal broaching, sawing, the role of cutting fluids in grinding type operations, factors affecting finish quality in abrasive belt grinding, use and handling of cutting fluids as well as many other interesting topics. Profusely illustrated, the book serves as a valuable reference source in machine shops.

(3) Interrupting Capacity Chart

A revised version of the "Interrupting Capacity Chart" is now available from the Westinghouse Electric Corp. The chart enables users of circuit breakers to select and order the proper breaker for each application. The chart has been revised to include the newly-designed Westinghouse breakers designated as the JK, JKL and the four Mark 75's. (SA 8163-A)

(4) Industrial Use of Isotopes

A booklet describing equipment and methods of radiographing all kinds of industrial products, has been published by Picker X-Ray Corp. The booklet discusses the advantages peculiar to isotopes in radiography, the selection of the proper isotope for a particular job and methods of making radiographic exposures. The bookle also contains a "chart of equivalent energies," showing typical exposure times required to radiograph various materials of varying thicknesses with some of the popular isotopes. Other sections explain how to solve the half-life problem of isotopes without downtime on the unit and list various radiation monitoring devices. The publication also outlines services available through the new Picker research center.

(5) Bar Processing Line

Loma Machine Mfg. Co. Inc., has announced a four-page bulletin which features the "Lomatic" automatic high speed machine for the continuous cold drawing, straightening, cutting and polishing of bars from coiled rod. Details of machine construction and operation are given, and various photographs illustrate a representative installation. (Bulletin 596)

(6) Speed-Draw Presses

A catalog covering the new line of speed-draw presses has been published by the Steelweld Machinery Div., The Cleveland Crane & Engineering Co. Diagrams depict the unusual patented mechanism which provides an operating speed that is 80 per cent over that of standard mechanical presses. The catalog gives construction details and complete specifications for machines ranging in capacity from 200 tons to 1250 tons. (Catalog No. 2029-A)

(7) Speed Reducers

Two new booklets containing detailed engineering data on Hewitt-Robins Inc.'s shaft-mounted, in-line helical and right-angle helical speed reducers are now available. Each booklet contains 24 pages of rating tables, selection procedures and other technical data useful to engineers specifying power transmission machinery. Booklet J-19 covers shaft-mounted reducers and J-18 deals with in-line and right-angle helical drives.

(8) Adjustable Speed Drives

A 12-page, booklet published by Reliance Electric and Engineering Co., gives detailed performance and application data on the complete line of Reliance all-electric, adjustable-speed V*S Jr. drives. Covering typical applications employing these drives from $\frac{1}{8}$ through 4 hp, the booklet is illustrated with photos and cartoon drawings. Condensed specifications, dimensions, and a gear-motor selection table are included. (Bulletin D-2507)

(9) Recorders

Information on their complete line of recording instruments, including dimensions and chart speeds, operating specifications, applications, features and accessories is available in a bulletin published by General Electric Co. Photographs of all models discussed are included. The bulletin also describes specialized recording instruments available, such as spectrophotometers, recording vibrometers, automatic oscillographs, self-balancing potentiometers and speed recording systems. (Bulletin GEA 6933)

(10) Modular Electrical Control Centers

A 16-page bulletin illustrating advantages and adaptability of a-c

motor control centers and including "plan-it-yourself" forms and instructions is available from Clark Controller Co. Fully illustrated, the booklet includes specifications, space requirement tables for control components and descriptions of Clark equipment designed for use in the control centers. (Bulletin PL 6200)

(11) Strip Tension Control

A new four-page report outlines the results achieved by a Pennsylvania steel mill in minimizing strip breakage on three continuous annealing lines. Instruments used in the Bailey Meter Co.'s Strip Tension Control System are listed along with other similar applications. (Performance Report S11-1)

(12) Mechanical Packings Catalog

A 64-page catalog, containing comprehensive information about the complete line of Johns-Manville mechanical packings, is now available. Text throughout is supplemented by a wide variety of photos, illustrations and specification charts and tables. Each packing style carries a prominent symbol to help the user quickly identify the media that the particular packing will best serve against. J-M has incorporated an explanation of these symbols as part of the catalog's Chemical Selection Chart, which in itself is unusually complete, listing more than 700 liquids commonly encountered in process industries. A simplified Packing Selection Chart helps the user relate his particular operation conditions (rotary, reciprocating, valve, etc.) to the most suitable packing construction style. A comprehensive section on how to determine the causes of packing trouble is offered as a further aid. Still another feature is an easy-to-scan table of contents plus a numerical and alphabetical indexing page on the inside back cover. (Form PK-131A)

(13) Sectional Belt Conveyor

A practical handbook on the use and selection of standardized Pre-Bilt sectional belt conveyors has been released by Link-Belt Co. These conveyors, pre-engineered and shop-assembled from matched Link-Belt components, are adaptable to a large proportion of belt conveyor applications and operating conditions. Pre-Bilt conveyors are part of Link-Belt's standard belt conveyor line. They are available in four belt widths of 18, 24, 30 and 36 in. A total of 22 components and accessories are listed in "Pre-Bilt Sectional Belt Conveyors," and also detailed engineering and selection data. Illustrations show installation applications in a variety of industries and typical layouts. (Book 2779)

(14) Control Valves

DeZurik Corp. has announced the release of a new bulletin describing its complete line of control valves. The new publication lists valve bodies and actuators and the accessory line available for their control valves. Valve sizing data is also included. A complete description of the DeZurik Eccentric Principle is diagrammed, and primary advantages of the valves are listed. (Bulletin 150)

(15) Packaged Oil Systems

Available from Trabon Engineering Corp. is a bulletin which illustrates and describes Meter-Mist Oil Systems which are available in 12 space-saving "packages" prewired, prepiped and complete with all components. The bulletin shows in words and pictures how an installation works protecting bearings and gears with proper lubrication. A handy table shows how to select Meter-Mist lubricator and reclassif er fittings. Included is information on the Trabon flow indicator fitting which quickly checks oil mist condition at remote bearing locations. (Bulletin 659)

(16) Descaling Machines

Pangborn Corp. has announced the publication of a bulletin which describes the complete line of Rotoblast descaling machines. Photos, diagrams, cut-aways and sketches show details and operating features of the Rotoblast wheels which provide the cleaning force of the mechanical descaling equipment. Various cabinet designs and material handling features appropriate to the type of work being descaled are described. The bulletin covers four-wheel and eight-wheel machines for descaling sheets, coils and plates; special machines for descaling rods, bars and wire; marginal descaling for pipe skelp; structural descaling equipment for angles, channels, H-bars and I-beams; and special installations for descaling billets and slabs. Other sections are devoted to blast stream coverage, operating controls, maintenance factors and abrasive cleaning and recycling equipment. Blast cleaning and pickling processes are compared in regard to initial and operating costs, time, manpower and floor space requirements, automation quality of finish and other considerations. Special features such as new "Wear-Resist" wear plates are discussed and related equipment such as the Roto-sander and the new blast cleaning steel abrasives are also covered. The bulletin also includes a number of illustrated case histories of Rotoblast descaling in action in steel and steel processing plants throughout the country. (Bulletin No. 609)

(17) Generator Brush Maintenance Manual

A brush maintenance manual for low voltage generators is available from National Carbon Co., Div. of Union Carbide Corp. The 16-page illustrated booklet contains practical tips on brush operation and maintenance on high-current, low-voltage generators used in electrolytic processes. Included is a discussion of metal-graphite brushes used in plating generators, together with explanations of contact drop, friction, resistivity and commutator surfacing. Other information for the electrical maintenance man includes sections on the facing-in of new brushes, dust removal, selective action and factors affecting brush life. (Booklet CP-3004)

(18) Thermocouple Catalog

A newly-revised, fully illustrated catalog offers complete information about Leeds & Northrup Co.'s full line of thermocouples and thermocouple components and accessories. This publication lists and describes standard assemblies in protecting tubes and wells for general applications; specialized thermocouples and assemblies for laboratory and industrial applications; and an extensive line of bare and insulated thermocouple wires, replacement elements, ceramic insulators, metal and ceramic protecting tubes, wells, terminal heads and extension leadwires. Recommendations are given on the choice and use of thermocouples and assemblies and on the limitations of protecting tube and well materials. (Catalog EN-S2)

(19) Metal Packings

A bulletin, dealing with the subject of metal packings for pumps, engines and compressors, has been published by the Garlock Packing Co. The 24-page booklet contains comprehensive data for correct selection, application and installation of metal packing and is complete with explanatory illustrations. The bulletin is designed specifically to acquaint users with pressure temperature and other service requirements relative to the various kinds of metal packing currently available. The first section describes free-floating metal packing, taking in detail the annular solid-cup type, high pressure packing and the split-case multi-groove type. Next in order are subdivisions on metal rod packing rings, metal scraper rings, metallic or non-floating packing and piston rings. The final section discusses testing and service facilities to assist users in selecting and maintaining metal packing. (Bulletin AD-166)

(20) Drive Catalog

A 96-page catalog, published by Reliance Electric and Engineering Co., explains in brief copy and many photos and drawings the wide assortment of styles, modifications and accessories available in the complete line of Reeves mechanical variable-speed motodrives. The catalog includes construction features, specifications, speed and rating tables and pricing information. (Catalog M-592)

(21) Gear Speed Reducers

Helical gear speed reducers are discussed in a booklet published by Link-Belt Co. This 20-page book consolidates all of the company's expanded line of helical gear speed reducer sizes in double, triple and quadruple reductions. Tables of load classes and service factors for all helical gear speed reducers are included. Horsepower and torque ratings, dimensions, overhung load for high and low speed shafts and mounting arrangements are given along with a résumé of construction features. The publication also contains selection information on motor couplings and geared flexible couplings designed for use on their helical gear speed reducers. (Book 2751)

(22) Mechanical Dust Collectors

Recent improvements in mechanical dust collectors including a new involute design are described in a technical bulletin published by Research-Cottrell, Inc. The new bulletin contains detailed drawings and application diagrams about the involute design recently announced by the company. Also included is technical information on a new hopper discharge valve and larger diameter tubes for the high efficiency design. New steel mesh liners incorporated with castable cements for handling abrasive dust conditions are described. The wide range of sizes and possible arrangements in which the new Involute Cyclo-trell is available is also listed. (Bulletin 300)

(23) Tab-Weld Resistors

A bulletin which describes their tab-weld resistors has been published by the Electric Controller & Mfg. Co., a Div. of Square D. Co. The bulletin shows the construction features of tab-weld resistors, and explains how these features contribute to minimum maintenance. Also included is an easy-to-use selection table which covers ratings from 13 to 500 amperes continuous for various section lengths. Tab-weld resistors are particularly suited to severe-duty jobs where vibration-proof, nonbreakable construction is important. (Bulletin 6715)

(24) Grouting

The most effective methods for grouting the different basic types of heavy industrial equipment are explained with text and photos in a Master Builders Co. publication. Featuring the use of nonshrink Embeco pre-mixed grout the bulletin details methods and techniques of good grouting practice. Diagrams, charts and photos cover preparatory steps, forming, selecting materials, mixing and placing the grout with the object of obtaining maximum bearing of machine bedplate on grout. (Bulletin EPMG 2A)

(25) Ultra-High-Pressure Blast Furnace

A 30-page description of a new ultra-high-pressure blast furnace, utilizing a 40 psig top pressure to double pig iron output, has been prepared by Koppers Co., Inc. This literature includes an economic analysis of the new furnace, and contains twelve drawings and charts.

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50	CUNNINGHAM CO., M. E.	BULLETIN No. 613-D-Rev.	Slab and bloom marker
51	EDDYSTONE DIV., BALDWIN-LIMA-HAMILTON CORP.	BULLETIN No. 7001	Fabricating jobs
52	EUCLID ELECTRIC & MFG. CO., THE	BULLETIN No. 2017	Push-button stations
53	FOXBORO CO.	BULLETIN 21-10	Electronic controls
54	FRANTZ CO., INC., S. G.	BULLETIN PM-44	Magnetic separators
55	GARLOCK PACKING CO., THE	CATALOG 20	Oil seals
56	GENERAL ELECTRIC CO.		Crane controls and wound rotor motor
57	GENERAL ELECTRIC CO.	BULLETIN GEA-6893	Motor controls
58	GENERAL ELECTRIC CO.	BULLETIN GEA-6947	Automatic gage control
59	JOY MANUFACTURING CO.	BULLETIN 359-68	Conveyor idlers
60	KINNEY ENGINEERS, INC., S. P.	BULLETIN 501.11	Automatic self-cleaning strainers
61	LARCO, INC.	BULLETIN AC-573	Crane cab and pulpit air conditioners (aire-rectifiers)
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63	RAMTITE CO.		Plastic and castable refractories
64	ROLLWAY BEARING CO., INC.		Capacity and size ranges of bearings
65	SHEFFIELD CORP., THE	DATA SHEET NO. 113-57	Measuray gage
66	TAYLOR INSTRUMENT COMPANIES	CATALOG 98335	Electronic process control
67	TEXACO INC.		Organized lubrication
68	TORRINGTON CO., THE	CATALOG NO. 258	Spherical roller bearings
69	WAGNER ELECTRIC CORP.	BULLETINS TU-205, TU-214	Transformers
70	WESTERN GEAR CORP.	BULLETIN 5802	Speed reducers
71	WESTERN PRECIPITATION CORP.	BULLETIN NO. F105	Filter systems
72	WHEELABRATOR CORP.	CATALOG 562-D	Ultra-filtration equipment
73	WHEELABRATOR CORP.	BULLETIN 148-D	Automation of wire production through blast descaling
74	WHITING CORP.	BULLETIN NO. FO-10	Furnace control
75	YODER CO., THE		Slitters

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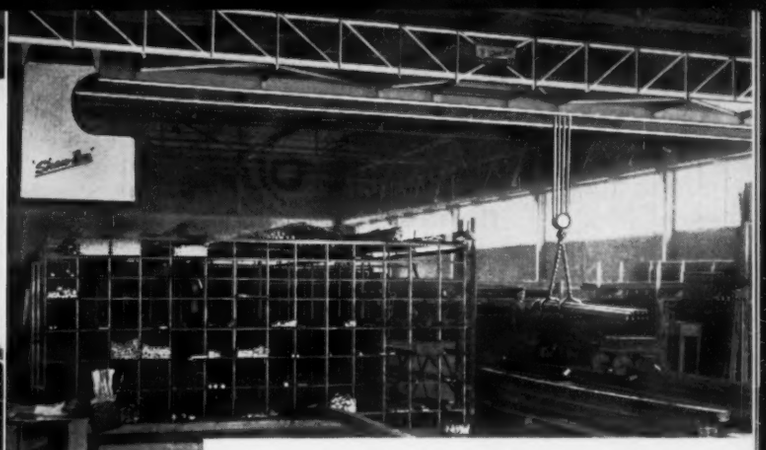
SC Crane speeds outdoor storage. This type of heavy industrial crane is custom built of standardized components. Capacities range from 5 to 40 tons; spans to 120 feet. 3 or 4 motor. Floor or cage operated.

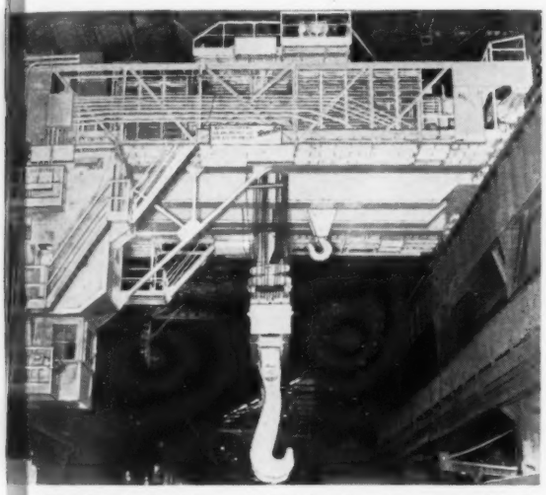


SB Crane on the job in a steel warehouse. This class of standardized crane is built in capacities from 5 to 40 tons; spans to 100 feet. Many built-in "plus values" insure top performance and low operating costs in the severest service.

PROOF

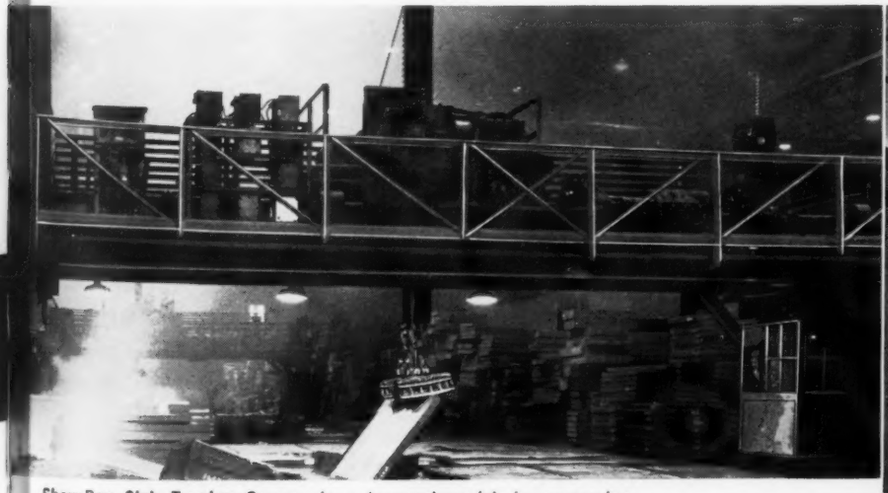
of Shaw-Box Crane quality and reliable performance is evidenced by more than 70 years of rapidly growing acceptance from all kinds of industries.

We build all types of cranes to AISE specs or to meet individual standards of structural durability and operational efficiency and economy. Your inquiry is invited.

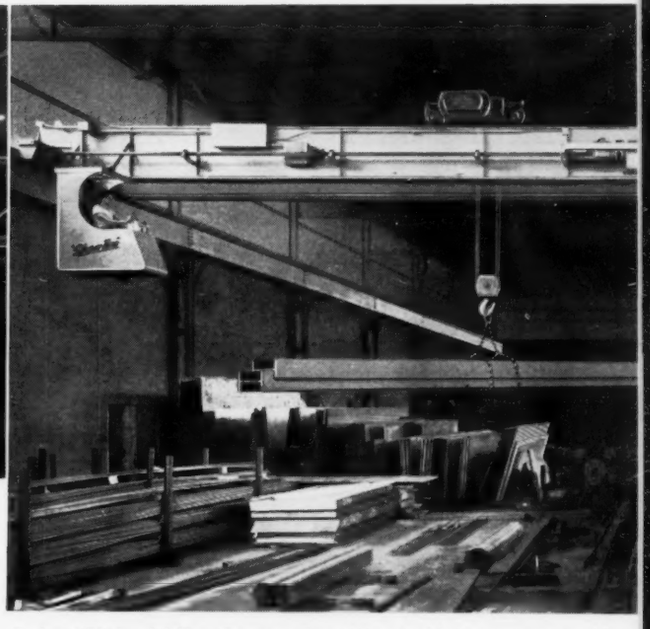


Shaw-Box Ladle Crane. A 4-girder, 9-motor crane with 54 foot span. 90-ton ladle holds 200 tons of molten steel. 75-ton auxiliary trolley handles lighter loads.

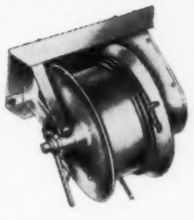
Shaw-Box Bucket Magnet Gantry Crane. Our gantries are serving the steel industry to handle plate, slabs, and scrap. We build them for other industries as well, in any desired capacity.



Shaw-Box Slab Turning Cranes do a tremendous job in conserving manpower and reducing costs around the clock. Rigid, non-whipping construction is combined with the utmost resistance to impacts.



Series "D" Load Lifter Cranes. Capacities to 20 tons, spans to 80 feet. Designed for average industrial service. Components are so highly standardized, you can buy your crane from a catalog.



Soaking Pit Cover Carriages are not only made by Shaw-Box, but we also produce the reliable spring drive cable reels that supply current to the carriages. These reels are also widely used on magnet equipped cranes.

59K-1-A

OVERHEAD CRANES FOR ALL INDUSTRY

Products of

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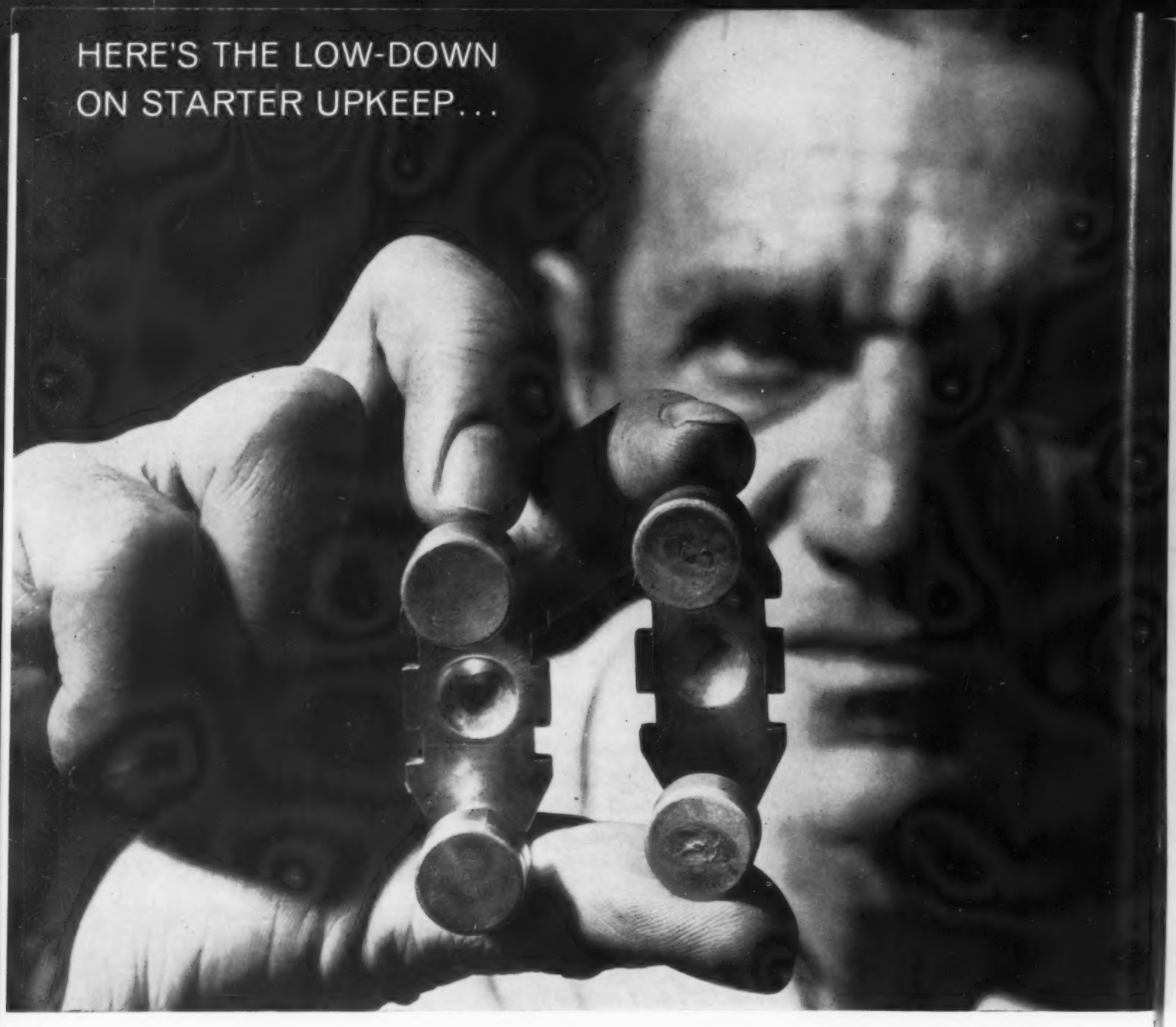
Shaw-Box Crane & Hoist Division • Muskegon, Michigan

In Canada: Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario



Can your starter contact tips match this before-and-after comparison?

The unretouched photograph above shows two sets of contact tips from a Clark Type "CY" A-C Motor Starter. One set has seen a year of continuous hard service with frequently as many as 5,000 operations per hour. The other set is brand new – unused.

Which contact tips were actually in service for one year? The obvious, but not too obvious clue is the slight discoloration and minute pitting in the tips at right above.

But you can easily see for yourself that even after one year of steady operation these tips show very little evidence of wear. Their present condition will assure many more years of dependable service, free of maintenance.

The secret? Clark's exclusive "arc quenching" principle incorporating the use of strong, multi-turn magnetic blowouts and double-break contacts.

The action of the magnetic field not only forces the arc to rotate, moving it continually over contact surfaces, but tends to "quench" it at the same time. Result: Less wear on contact tips and fewer maintenance headaches.

There are many more good reasons why the Clark Type "CY" Starter is your best *preventive* maintenance buy. For complete details contact your nearest Clark Controller sales office or distributor. Or, write direct. 931

The **CLARK CONTROLLER** *Company*

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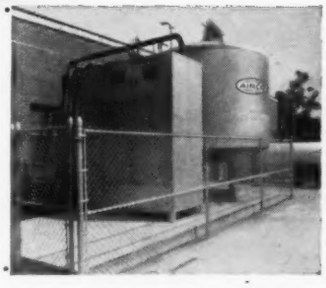
99.5% pure oxygen (O_2) ...by the ton or by the cylinder ... to a convenient location, inside or outside your plant ... for any process ... with absolute dependability

From more than 100 distribution and production points Airco today supplies American industry with oxygen and other high purity industrial gases. For the chemical industry ... missile fuel systems ... machine and manual cutting and welding ... steel making and processing ... flame hardening ... flame cleaning ... and for medical therapy and high altitude flight.

If you want to use oxygen for a new application or to improve the performance of current applications, Airco facilities are as near as your telephone.

Call in the Airco Engineering Service Representative. He is qualified to assist in planning a process with you from the very start. He is a long time expert in application techniques. He knows the rugged types of apparatus essential to oxygen processes. He knows in-plant distribution to consumption points. He knows how to make sure your supply will be ample at all times.

For O_2 ... Airco.



Right: Airco liquid oxygen station "installed" on customer site to assure large quantity storage for an uninterrupted supply.

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after years of trouble free service

...Downtime—30 seconds with

HUNT'S *NEW* PDQ VALVE

You asked for a TOTALLY ACCESSIBLE air control valve

We built it. It took us three years . . . designing, field testing, redesigning. Here it is . . . the PDQ. The day (years in the future) when you have to change valves, if it's a Hunt PDQ, you do three things: (A) just loosen 2 cap screws; (B) twist pilot cap; (C) remove pilot cap and valve housing. No pipe to pull. No electrical splices to sever. No junction boxes to open. No electrical conduit to remove. It's plug-in.

Total downtime? I've replaced this valve myself in less than 30 seconds. You buy **trouble-free performance** and **minimum downtime.** I sell **trouble-free performance** . . . and **a new minimum downtime record.** Write today.

N. C. HUNT, PRESIDENT

HUNT VALVE COMPANY · SALEM, OHIO, U. S. A.

- ☑ Accessibility
- ☐ Simplicity
- ☐ Speed and Capacity
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The Hunt PDQ Valve tops them all in every class.

Next month . . . the SIMPLICITY story.

HUNT HVC ***Quick-As-Wink*** AIR & HYDRAULIC CONTROL VALVES

Two of Three Continuous Galvanizing Lines at Inland Steel Company, Indiana Harbor.

Continuous Processing Lines

CONTINUOUS GALVANIZING

ELECTROLYTIC TINNING

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Our experience with Processing Lines dates back to the earliest production of strip in coils. This experience includes the design and building of many Continuous Electrolytic Tinning and Continuous Annealing and Normalizing Lines. In the field of continuous galvanizing, we have built more lines than all manufacturers combined.

In these days of higher and higher speeds, combined with larger coil diameters and weights, equipment must be rugged to stand up to 21-turn operation without long maintenance shutdowns. A trademark of Aetna-Standard is . . . good engineering and ruggedness of equipment.

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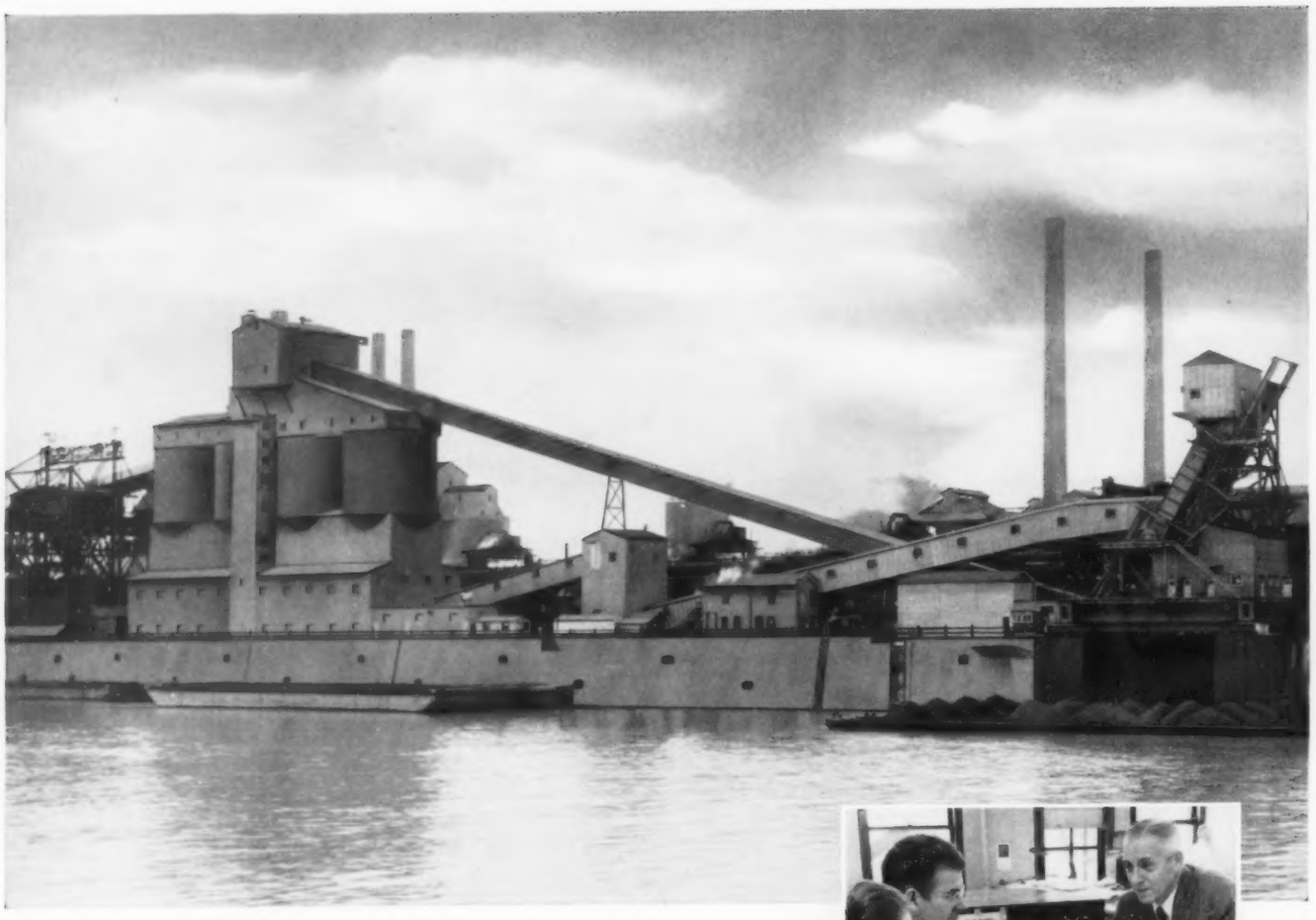
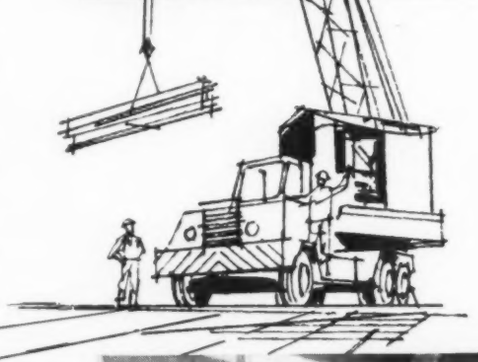


CAPACITY! FLEXIBILITY! ECONOMY! PERFORMANCE! . . . everything you want in a material handling plant

You determine exact performance specifications for the material handling plant you want. Roberts & Schaefer can meet your specifications, however exacting, with all required processing, distributing and storage systems. It takes specialized experience, creative engineering skills and strong resources to deliver . . . as Roberts & Schaefer can and does. You can depend on R&S for any portion of the project or for the complete job — design, engineering, fabrication, construction.



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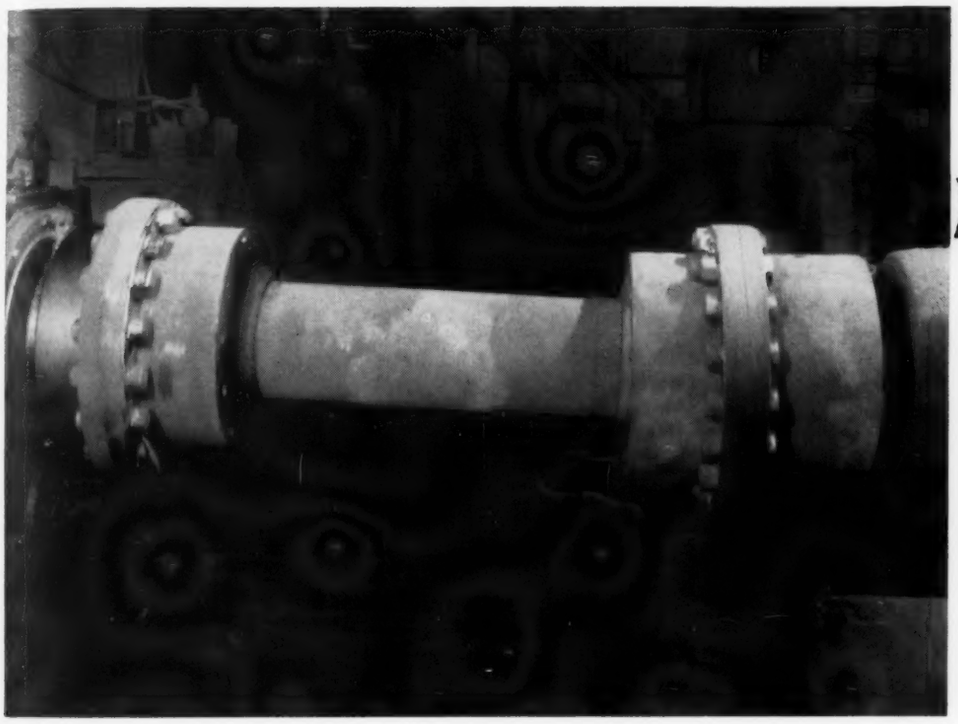
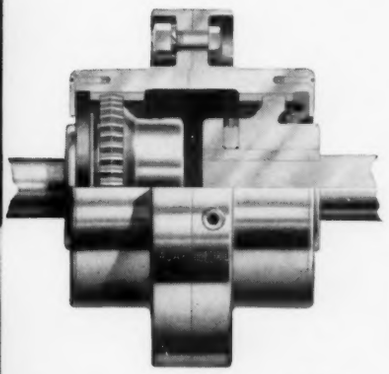
AJAX DIHEDRAL Floating Shaft COUPLINGS





Cut-a-way view of an AJAX DIHEDRAL COUPLING shows arrangement of hub gears with AJAX patented Dihedral tooth shape.

AJAX DIHEDRAL GEAR COUPLINGS are made in a wide range of standard double engagement, floating shaft, mill motor and spindle types.

HANDLING HEAVY DUTY ANGULAR DRIVE FOR OVER 2 YEARS WITH ZERO MAINTENANCE COST

Photograph shows an Ajax Dihedral Floating Shaft Coupling which replaced an old style slipper joint used to handle the angular drive requirements between driving and driven units. This coupling has been in continuous operation for over two years with practically no maintenance cost as contrasted to the old style drive which had to be replaced every three to four weeks.

AJAX Dihedral Couplings give you mile-a-minute speed, smooth running constant peripheral velocity, freedom from backlash, close gauge tolerance, better surface finish, longer roll life, and far less down time.

Specially designed seals assure adequate lubrication, long life, reduced maintenance, and clean shop conditions.

Performance records of AJAX Dihedral Couplings are responsible for their being written into the specifications of the world's finest mills. Whether you are designing, building, buying or modernizing your mill, it will pay you to take advantage of the broad experience gained by AJAX engineers since their introduction of these radically improved Drives.

A reprint of a paper presented before the Association of Iron and Steel Engineers will give you authoritative information covering their contribution to mill performance. Consult the yellow pages of your phone book, or write for AJAX Bulletin 64.

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MODERNIZE FOR PROFITS ...through automation

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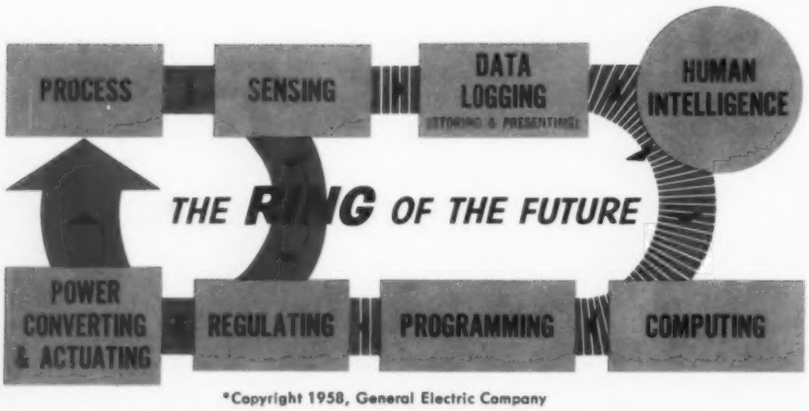

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... General Electric's approach to automation, helps you blend the products of today into the systems of tomorrow . . . provides a logical, step-by-step approach to modernization through automation. Start your program now. Call your General Electric Apparatus Sales Office for complete information about the "Ring of the Future" and how it can be applied to:

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You can meet your competitive challenge decisively with a planned program of modernization . . . modernization that provides greater machine flexibility, higher efficiency and output from your metal rolling and processing systems. General Electric stands ready to assist you in blending the products of today into the systems of tomorrow. To learn more about modernization through automation, mail the coupon below for General Electric's "Ring of the Future"* kit.

For a 13" x 29" lithograph copy of this painting suitable for framing, write on your letterhead to address below.

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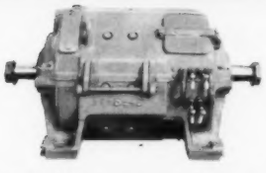

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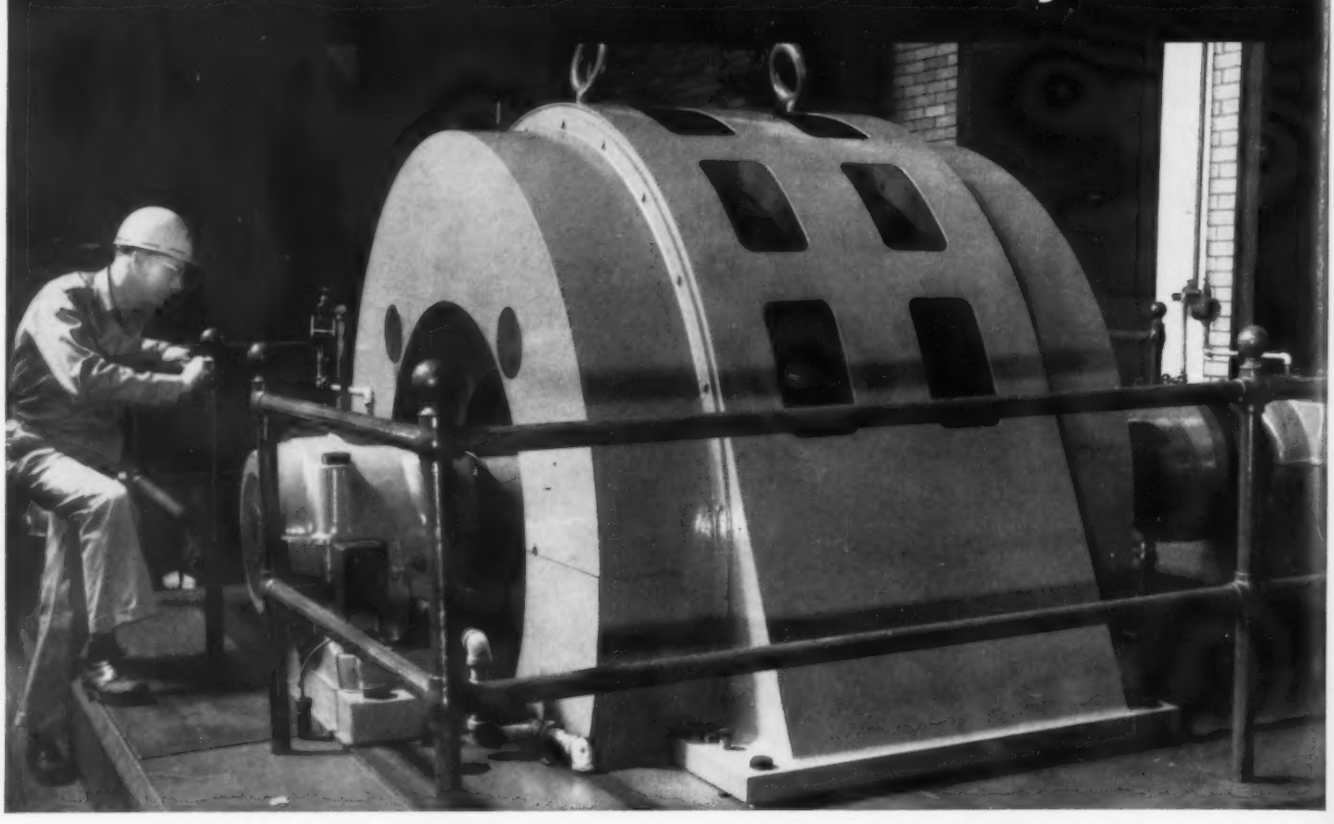
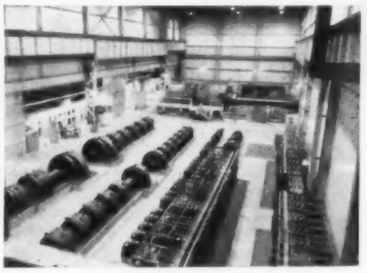


cleaned by Wheelabrator® air filters

Dust-free atmosphere is essential to dependable and continuous motor operation, and Ultra-Filtration can provide the degree of air purity you require, at minimum cost. Savings in motor and blower maintenance costs alone can return more than the cost of Ultra-Filtration equipment in a short time.

In prominent American and Canadian steel plants, Wheelabrator Ultra-Filtration installations are providing over 5,000,000 cfm of super-clean air for motor rooms, electrical equipment, control rooms and turbo blowers. Collection efficiencies above 99% by weight and 95% by blackness test are regularly maintained, even when filtering sub-micron size particles.

In cost of operation, Wheelabrator Ultra-Filtration equipment has proven to be the most economical method that provides the necessary level of filtering efficiency. No liquids, oils or tacky materials are involved in its operation. There is no problem of sludge removal. In fact, not one cent for maintenance has been spent in filtering 364,000,000,000 cubic feet of air in a typical application.



For detailed information on Ultra-Filtration equipment in steel mill applications, see your Wheelabrator Dust and Fume Engineer or write to Wheelabrator Corp., 396 S. Byrkit St., Mishawaka, Ind. In Canada, Wheelabrator Corp., P. O. Box 490, Scarborough, Ontario.

WRITE TODAY for your copy of Catalog 562-D, illustrating uses of Wheelabrator Dustube and Ultra-Filtration equipment in steel mills and other industries.

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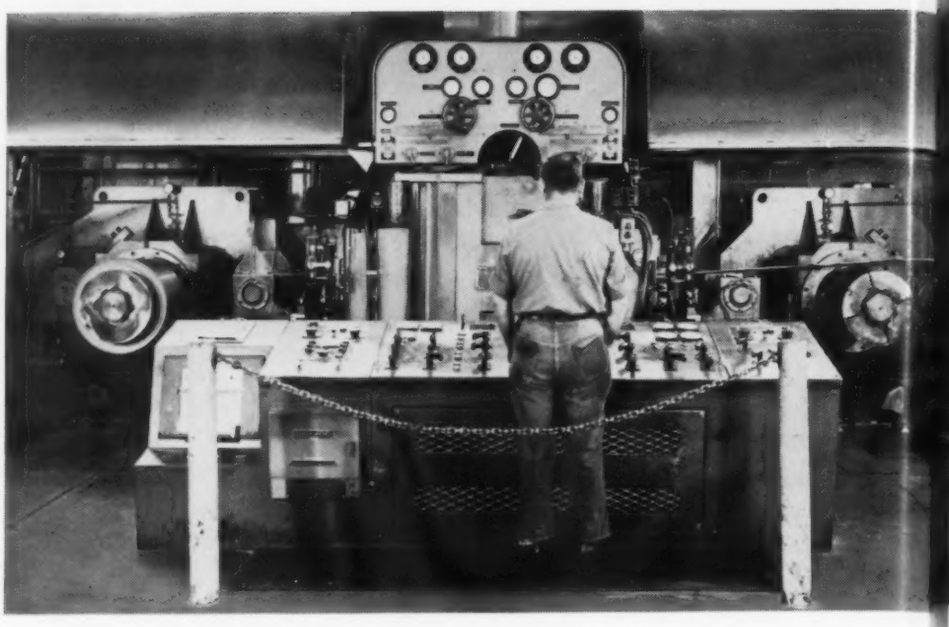
DUST AND FUME CONTROL

YOU GET MORE KNOW-HOW WHEN YOUR "SPECS" READ HYATT

because HYATT has built *millions* more cylindrical roller bearings than anyone else for two thirds of a century. And every year for the last 67 years we have learned to make them run longer, smoother, more reliably. Remember, *no bearings carry radial loads like cylindrical bearings—and nobody knows them like HYATT.* Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey.

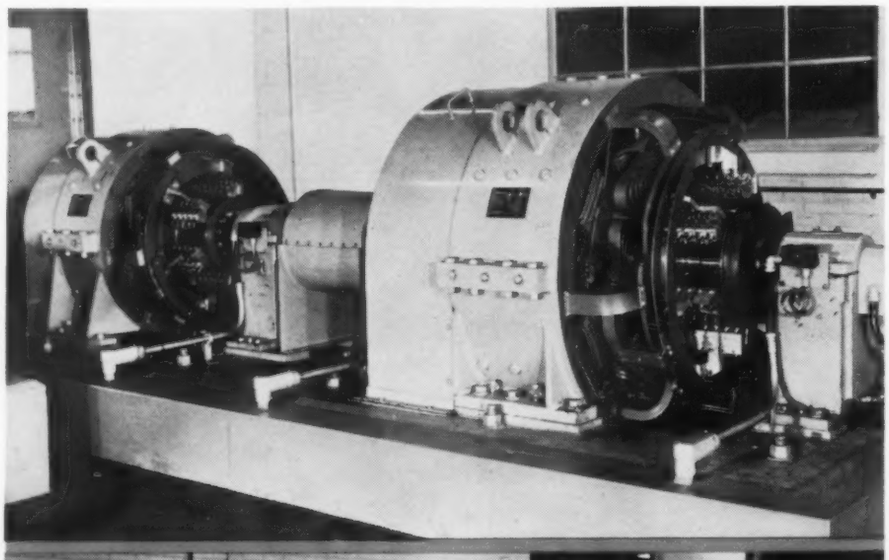
HYATT HY-ROLL BEARINGS

IN ROLLER BEARINGS HYATT IS THE WORD FOR GM GENERAL MOTORS RELIABILITY



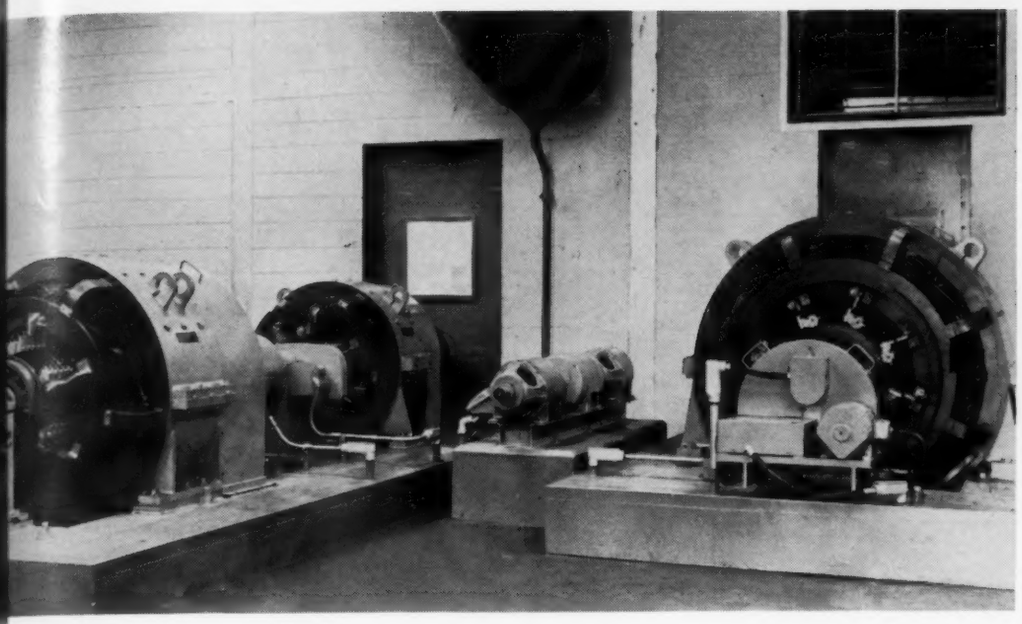
Operator faces control panel of the 26-in. reversing cold strip Sendzimir Mill. Specially designed to roll both high- and low-carbon strip steel to close tolerances, this mill features X-ray gages with automatic control and recording units which assure uniform high quality and extreme accuracy. Elliott engineered the complete automatically-controlled, self-correcting drive.

precision·



Close speed regulation and ample power at all loads is assured by the Elliott-engineered drive. The tandem unit shown here powers the left winding reel. The magnetic clutch between the 300-hp motor (left) and the 600-hp motor engages or disengages the larger motor, as required.

The Elliott adjustable-voltage system provides continuous speed adjustment for both the work rolls and the winding reels, from low threading speed up to 1500 fpm. Adjustable voltage is supplied by the four-unit Elliott motor-generator set seen here. Left to right, 1500-kw generator, 3000-hp synchronous motor, and twin 750-kw generators. All main drive machines are built with enclosures for updraft forced ventilation.



At the left is seen one of the winding reel tandem drives which enables the mill to handle a broad range of products. It consists of 600- and 300-hp motors operating at 400/1200 rpm, connected by a magnetic clutch. The main driven rolls are powered by the 1750-hp, 450/850 rpm Elliott Motor at the right.

controlled

The Stanley Works' new Sendzimir Mill at New Britain, Connecticut produces high- and low-carbon strip steel to meet the broadest range of dimensional specifications. Automatic speed synchronization of mill and reels provides strip uniformity and increased yield. Elliott engineered and furnished the complete "tailor-made" drive.

HOW ELLIOTT INDUSTRY ENGINEERING SERVES STEEL AND NON-FERROUS INDUSTRIES

Elliott has engineered complete mill drives and coordinated all associated equipment for virtually every type of mill for leading producers and fabricators.

Bulletin Q-23A describes the wide variety of Elliott experience in mill electrification.

Elliott's versatile, experienced Industry Engineering staff can help you increase production and cut costs.

ELLIOTT
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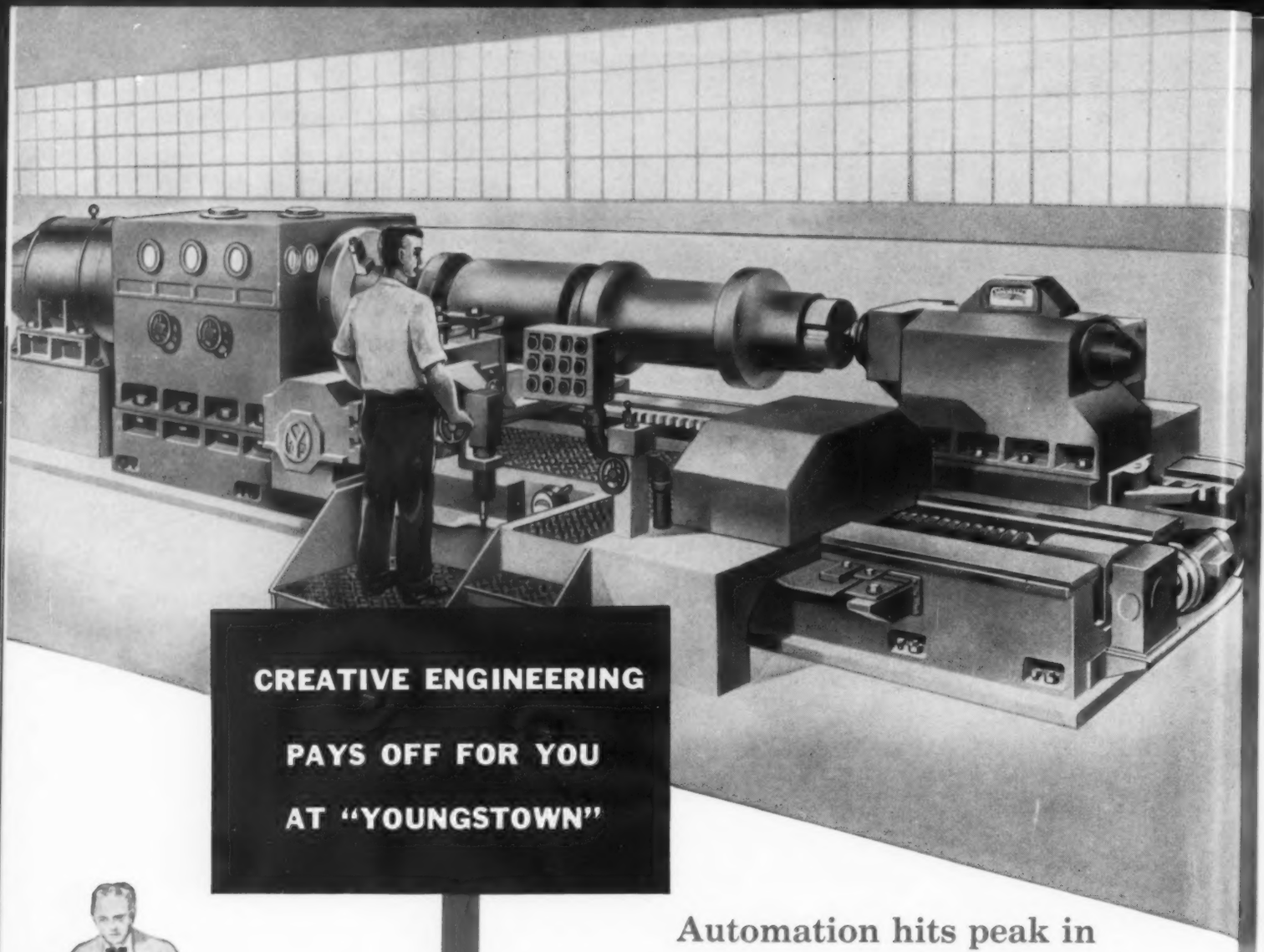
R10-1



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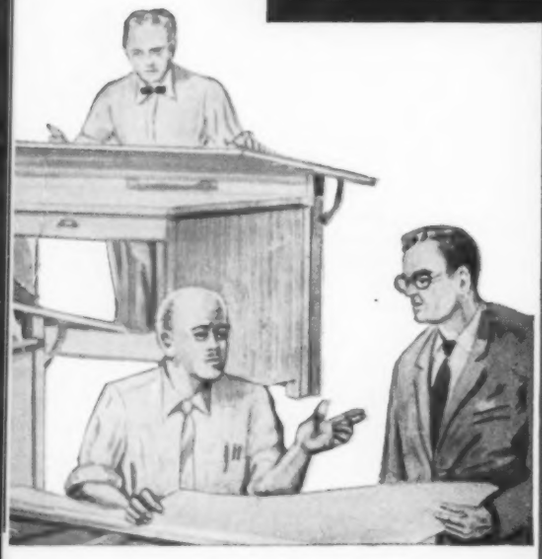

"YOUNGSTOWN" quality begins with the progressive ideas of our engineering staff (example: our new roll lathe design). Consult us . . . particularly on such completely integrated projects as pickling lines, scrubber lines, slitting lines, shearing lines, extrusion presses and auxiliaries, furnace charging equipment, runout tables . . . Paralloy and ductile iron rolls . . . Custom built equipment . . . all benefiting from our ¾ century of experience.

Automation hits peak in

"YOUNGSTOWN" CONTOUR ROLL LATHES

(Capacities 24"-36"-48"-60"-72")

The above sketch, made during construction, shows the typical design of "YF&M" contour roll lathes.

Automatically controlled, hydraulic or electric tracers which are "templet or numerically controlled" assure smooth operation, fine finish, and extremely close tolerances. Tool post and carriage are designed for use of either carbide-tipped tools or regular roll turning tools. Headstock has illuminated inspection ports . . . automatic lubrication . . . Timken roller bearings . . . herringbone gearing . . . Rugged throughout for extreme rigidity . . . No faceplate overhang. Higher headstock speeds can be furnished to accommodate ceramic tooling.

Heavy Duty spring-loaded tailstock with load indicator—avoids overloading of bearings. Housings—manually or hydraulically operated. Electric-Hydraulic Ragging attachment optional. Everything to meet specific requirements.

Write for complete information.

The Youngstown Foundry & Machine Co.

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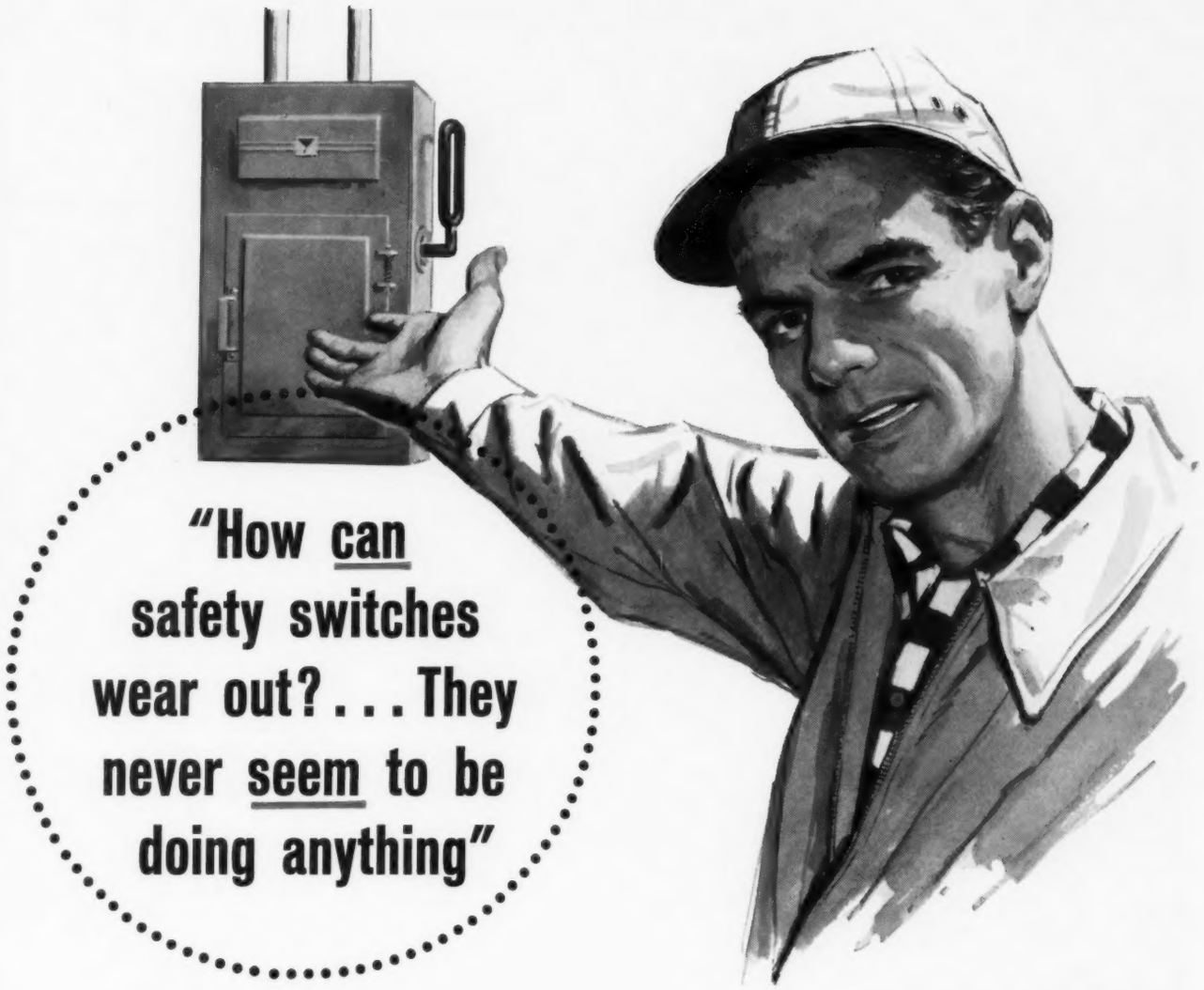
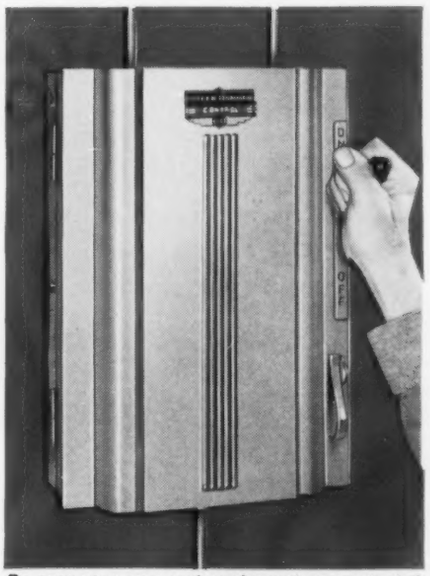


"How can safety switches wear out? . . . They never seem to be doing anything"

The fact that safety switches seem to be doing nothing at all until an emergency arises and somebody rushes to "pull the switch" is very deceptive. Actually, safety switches *work* every minute they are in service, fighting the ravages of unavoidable internal heating . . . and how well they are built decides how much *safety* your customer has when he really needs it.

Normal full-load current passing through the fuses in a safety switch generates considerable heat, temperatures as high as 700° F are not uncommon. This is not a criticism of fuses because they must operate close to their *melting* point at full load if they are to function properly when an overload occurs. But the continual heating of the switch mechanism in the confined enclosure creates a serious *heat* problem. Metal parts warp and corrode. Contacts loosen, then either weld or *burn up.*

Cutler-Hammer engineers tackled the problem of internal heating and licked it. Cutler-Hammer *Heat-Proof* Safety Switches use only selected heat resistive materials and a design that conducts away the trapped heat. Why settle for less when Cutler-Hammer *Heat-Proof* Safety Switches cost no more. Write today for your handy selection guide, C-H Merchandiser, Pub. EA100-X232. Cutler-Hammer Inc., Milwaukee 1, Wis.



Be sure your men and equipment are protected with *Heat-Proof* Cutler-Hammer Heavy Duty 4105 Safety Switches . . . choice of Mill Engineers everywhere.

CUTLER-HAMMER CONTROL C-H

CUTLER-HAMMER

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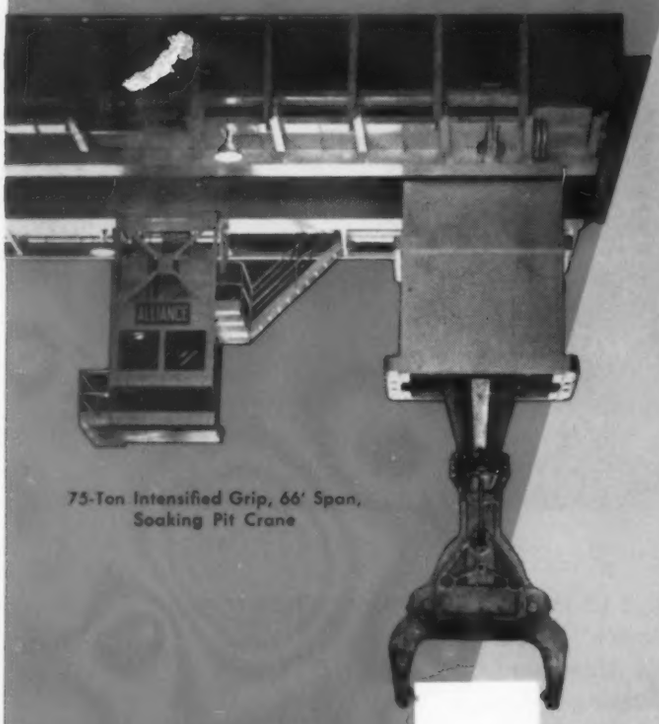
There's More in a CRANE Than BASIC MATERIAL



75-Ton Intensified Grip, 66' Span, Soaking Pit Crane

The soul of a crane is the creative thinking of ALLIANCE "Imagineering". Ruggedness, service and dependability are the unseen qualities of all ALLIANCE equipment. Equipment that has brought industry to . . .

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ALLIANCE FOR GREATER OVERALL RETURN FOR YOUR INVESTMENT

Give us the Runway... and We'll Lift the World.

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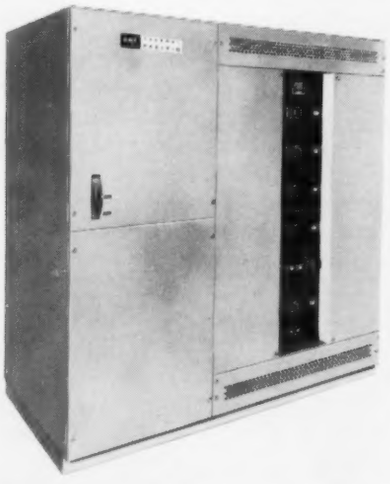
Equipment News...

PACKAGE POWER CENTERS

△ Package power centers, a new line of indoor unit substations, has been introduced by Federal Pacific Electric Co. Rated up to 500 kva, the new units are designed to transform and control power at primary voltages of 5 or 15 kv to secondary distribution voltages at the point of use. Each power center consists of a unit enclosure incorporating primary switch, transformer and secondary distribution sections.

Chief advantages of the unit are its compact size, operator safety and front access to all operating parts. The maximum over-all dimensions of the new units are 78 in. high, 98 in. long and 42 in. deep, making possible the conservation of valuable floor space.

Primary sections are available with 5 and 15 kv fused and nonfused load break switches, or with 5 and 7.2 kv fused and nonfused oil cutouts. An interlocked compartment containing high voltage fuses and front operated transformer tap changes assure complete protection



against accidental contact with high voltage components.

Transformer sections, suitable for operation on 5 and 15 kv primary systems, are available in a wide range of sizes from 45 through 500 kva. They feature a 3-phase, 60-cycle Class B dry-type transformer with four 2½ per cent full capacity taps.

Because the transformers are conservatively rated and mounted on vibration dampeners, the noise level is reduced below NEMA standards, making the new package power centers especially suitable for use in occupied areas or where personnel work close by.

Secondary sections have base assemblies engineered on modular dimensions, and predrilled mounting rails and bus bars that offer flexibility in accommodating any of the four basic types of components. These components are: DMB large air circuit breakers, rated 15 through 1600 amp, 600 volts; QMQB fusible switch units, rated 30 through 1200 amp, 600 volts; and PMS motor starter units, in a complete range of NEMA sizes 0 through 4 across-the-line starters and reversing starters through NEMA size 3.

Compactly constructed, package power centers are fabricated of 11 gage die-formed channels bolted together for maximum structural rigidity. The channels are prepunched to permit easy changes or additions to the system. Screw removable, front, rear and top cover plates completely enclose the unit.

STEEL FABRICATING PRODUCTION LINE

A new production line for structural steel fabrication was recently demonstrated by the Mulfab Corp., McKees Rocks, Pittsburgh, Pa., which is expected to reduce steel fabricating costs by more than 50 per cent. Because of an optical gaging device beams are accurately cut to size. In addition the equipment can simultaneously drill to very accurate tolerances both the flanges and the web without any layout. The overall line is 250 ft long, requiring only two men for the operation, for once the material is loaded onto a storage table, all movements (cutting to size, drilling, etc.) are performed by machines. This is the first unit of this type built by an American firm. A somewhat similar installation, built by a British firm for a fabricating company in the United States, has shown marked production economies. It is believed, however, that the British equipment costs double the approximately $200,000 needed for the complete unit which includes saws, drilling, gaging, and material handling transfer equipment which are part of the line.

GOGGLE VALVES

△ A series of new thermal expansion goggle valves for use on high pressure blast furnaces has been introduced by William M. Bailey Co. These are the first goggle valves developed with water-cooled flanges and parabolic silicone rubber seats in the goggle plate.

Designed for use on the large gas line between the dustcatcher and gas washer on high pressure furnaces, these valves are said to provide a tighter, more gas-proof seal than can be achieved with metal-to-metal seals. The water cooling feature protects the parabolic silicone rubber seats from heat damage. Construction is such that the seats can be replaced without taking the goggle plate out of the line. Sizes range from 72 to 120 in.

The goggle valves make use of the linear expansion and contraction of steel in three sets of tubes around the circumference for freeing and clamping the goggle plate.

MOTOR INSULATION

△ Insulation advances have enabled engineers at Westinghouse Electric Corp. to successfully operate a standard indoor-type motor out of doors. The motor, a dripproof, 500-hp, 2300-volt, induction motor equipped with now-standard "Thermalastic" insulation, has operated successfully for 2½ years.

In order to accelerate insulation degrading factors as much as possible, the motor has been operated under no-load conditions for 40 to 50 hr each week in an exposed area. At no-load, there is little heat generated to produce the usual drying effect. Also, the large amount of downtime over week ends gives ample opportunity for severe condensation.

The motor has operated through two complete winters and has been exposed to a typical northeastern climate, including snow, sleet, rain, dust and heat. "Thermalastic" insulation now used on all Westinghouse large motors, provides the only weather protection.

Periodic maintenance tests have been conducted, including dielectric absorption studies at various voltages and a d-c over-potential test at the 6-kv level as recommended in AIEE test specifications.

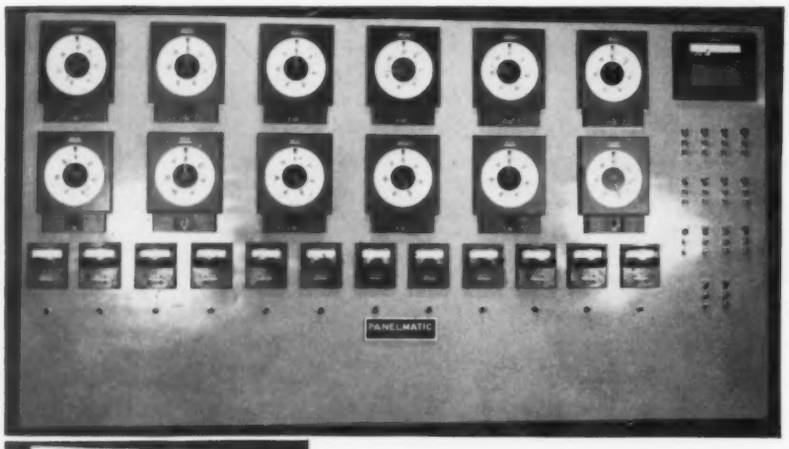
To date, the tests have revealed no indication of any pending difficulty. Westinghouse plans to continue to operate the motor for an indefinite time. A very detailed examination of the mechanical features of the motor will also be made at the next periodic test.

PATCH BRICK

△ A new basic refractory patching brick for furnace roofs has been patented by Harbison-Walker Refractories Co.

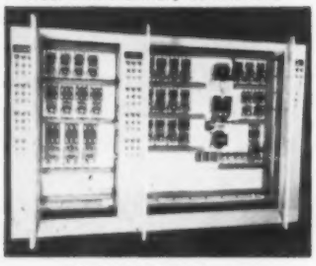
Until now, basic roof patching was accomplished largely by securing the patch brick to tie rods or other supports in the furnace roof structure. This system, while basically sound, requires more time and is therefore more expensive than predicted for the new side-attachment brick.

This new special basic shape patching brick involves a slot in the case and a recess in the brick directly



Chemical Process Control Panel

Steel Mill Auxiliary Benchboard



Motor Control Center

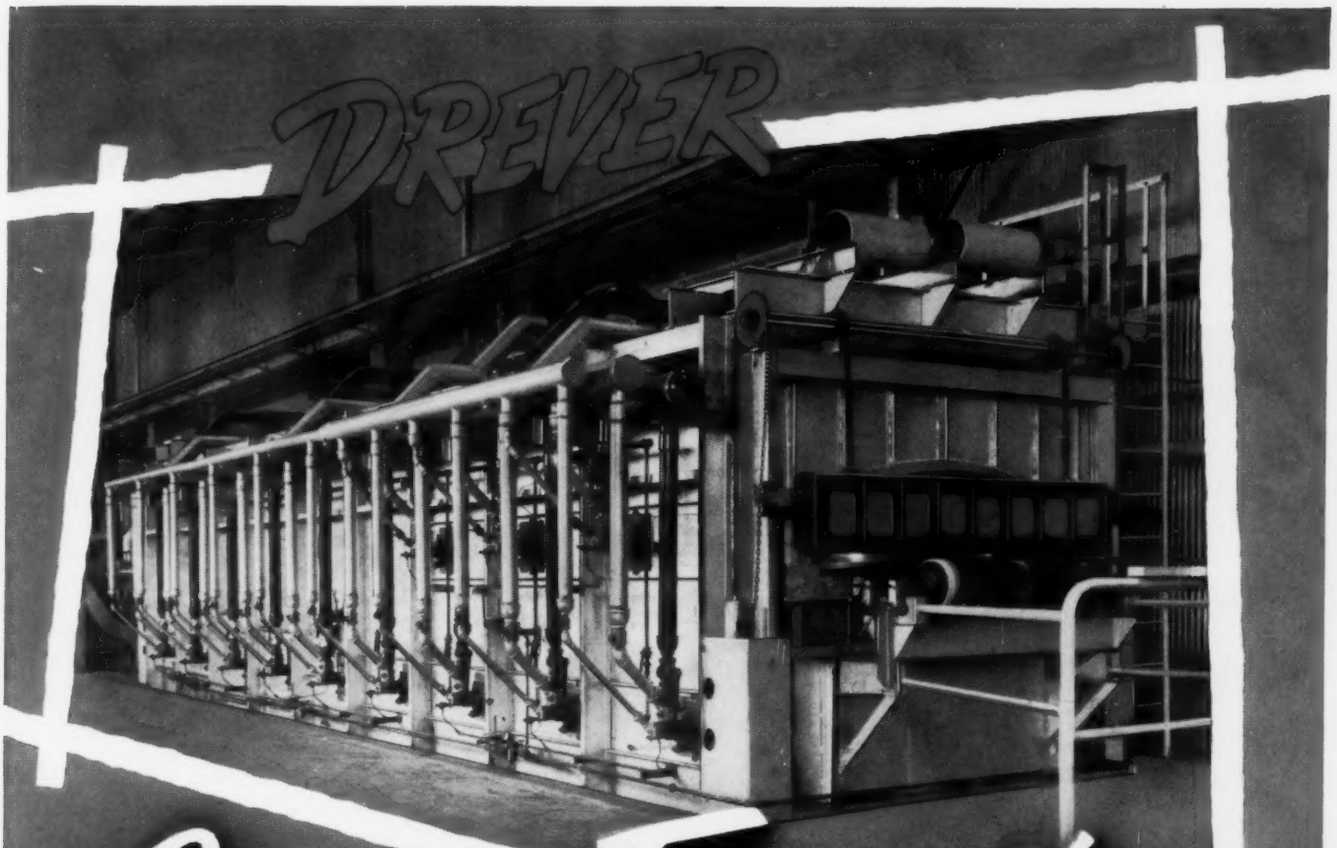
Complete, Custom-built Electrical, Pneumatic and Hydraulic CONTROL PANELS

We have complete metal working facilities to build the special enclosure. We regularly mount the components along with wiring and piping to meet all standards and specifications.

WRITE PANELMATIC, INC. 571 ANDREWS AVE. YOUNGSTOWN 2, O. FOR BULLETIN P-100A.

PANELMATIC

YOUNGSTOWN, OHIO



Catenary Furnaces

A 12,000 lbs/hour Fuel-fired Catenary Annealing Furnace for stainless strip used in line with spray quench followed by descaling and pickling baths.

FURNACE CHARACTERISTICS

Inside Dimensions 50'-0" long x 7'-0" wide x 6'-8 3/8" high

Fuel Input ..... 1,800,000 BTU/hour

Operating Temperature Range . . 1200 to 2250°F

Stainless Strip . . . . . Cold reduced—annealed in gauges from 0.007" to 0.125"

Stainless Strip . . . . . Hot rolled—annealed in gauges from 0.093" to 0.200"

Three (3) zone proportioning control

Complete control over fuel-air ratio to maintain desired atmosphere in furnace

DREVER COMPANY

RED LION RD. & PHILMONT AVE., BETHAYRES, PA.

23

SCHLOEMANN

By courtesy of Stewarts & Lloyds

The new mill stand, ready for the change over, alongside the old stand, through which the last ingot is passing.

Installation of a Blooming and Slabbing Mill in Record Time

Losses are incurred every day a plant stands idle. Therefore, when a rolling mill is to be converted or expanded, rolling mill engineers aim at keeping idle time to a minimum. Experience enables installation work to proceed rapidly and smoothly.

To quote the trade press, a "world record" was established for the speedy installation of a heavy rolling mill at the plant of Stewarts & Lloyds, Corby, England – through the excellent cooperation of all concerned. Due to the expansion of the mill schedule, the blooming mill supplied by SCHLOEMANN in 1937 had to be renovated. 30,000 cu.ft. of old foundations and 1,500 tons of machine components had to be removed; 50,000 cu.ft. of new foundations had to be laid, and sub-assemblies weighing 1,750 tons installed. The last bloom was rolled on the old mill on December 5th, 1958, and 10 days and 10 hours later, the new 48 in. rolling mill (1st stage) designed by SCHLOEMANN was put into operation without a trial run. After only eight days, weekly production was close to the 30,000 ton planned output.

The rolling mill is laid out to break down cast ingots and slab ingots weighing from 5 to 10 tons, at an annual production rate of $1^1/_2$ million tons. Costs resulting from interrupted production were minimized, and the effort involved through the speedy conversion was more than justified.

FELLER ENGINEERING COMPANY 1161 Empire Building, Pittsburgh 22, Pa.

underneath the slot. This permits the insertion of a support clip, which engages the slot in the case to provide positive support to the shape. In this manner, patch bricks can be supported by adjacent bricks rather than tie-rods. The clip can take on a variety of shapes. Special clips can be provided for specific furnace installations.

There is the additional possibility of supporting two bricks from a single clip by allowing a long enough protrusion from the clip to penetrate through the brick case and also through a slot in the brick case adjacent to it. This method, however, would require the support of the clip on a rod or other suitable support.

BLAST CLEANING BARREL

Δ A new addition to its line of heavy-duty blast cleaning barrels has been announced by Pangborn Corp.

The 15-cu ft Rotoblast barrel is designed to provide the first heavy-duty type barrel of medium size to clean large castings weighing up to 500 lb each. It will handle a batch load of 2700 lb.

Available with standard controls or in semi- or completely automated types, the unit incorporates a 30-hp Rotoblast wheel which delivers 50,000 lb of abrasive per hour for rapid cleaning at low cost.

The interior construction features "wear resist" steel plates as standard equipment. This long wearing super-tough alloy lasts up to 100 times longer than mild steel and insures low maintenance costs and less downtime for parts replacement.

The rugged, close-fitting slat-type work conveyor incorporates new design refinements making it virtually jam proof and quiet running. Conveyor tension is quickly and easily adjusted from outside without dismantling or unloading. Should the conveyor jam while running in either direction (blasting or unloading), an automatic torque arm immediately disengages the shaft-mounted reducer drive and stops the work conveyor until the jam is cleared and the torque arm manually reengaged.

The blast cabinet is constructed of welded steel plates, completely sealed and dust tight. The jam-proof two-piece barrel door travels on rollers in labyrinth-sealed guides which contain no gaskets or rubber seals. The door and guides are wider than the barrel opening: this eliminates damage to the guides during loading and prevents abrasive from entering the labyrinth seals. When closed, the door is abrasive and dust tight.

The door guides above the top deck accommodate the open door in a vertical position, permitting easy access to the upper barrel deck where the abrasive separator is mounted.

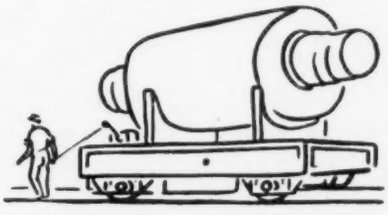
Abrasive cleaning and recycling consists of four phases. First, the abrasive is coarse screened in the bottom of the cabinet hopper. Secondly, the abrasive is passed by screw conveyor into a patented 16-in. scalping drum where all coarse particles larger than abrasive size are removed and ejected into floor-level containers. The perforated scalping drum is longitudinally louvered to positively prevent the passage of all foreign materials such as nails, wire, rod segments, etc. Third, a newly-designed bucket-type elevator then lifts and deposits

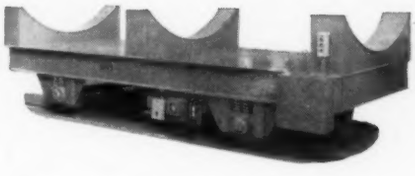
CUSTOM DESIGNED

for

payload

efficiency

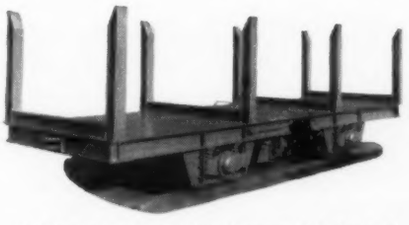




20-Ton Storage Battery with Cradle for Pipe

ATLAS

SAFETY-TYPE TRANSFERS



40-Ton Safety-Type Walk-Along with Stake Bed

- *SAFE — because one lever controls forward-reverse-stop.*
- *SAFE — because car stops when operator releases lever.*

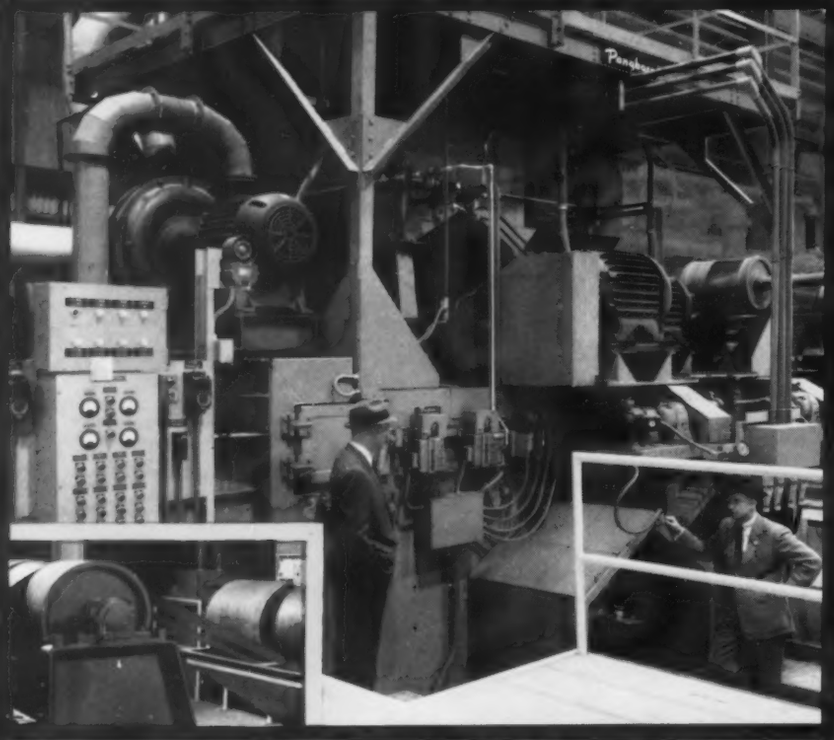
Atlas transfer equipment is designed for your specific load and production needs. Optional power includes Storage Battery (Walk-Along or Rider-Type) • Gas-Electric • Diesel-Electric • Cable Reel AC • Cable Reel DC • Cable Reel AC With Fluid Coupling • also remotely controlled cars without trailing cable.

Write today for Bulletin 1283

ATLAS CAR & MFG. CO.
1100 IVANHOE ROAD
CLEVELAND 10, OHIO

ENGINEERS AND MANUFACTURERS SINCE 1896

PUSH-BUTTON DESCALING WITH ROTOBLAST!



Universal Cyclops uses Pangborn Rotoblast Descaling for flexibility in automation

Devoted entirely to the production of cold rolled stainless steel strip, the new Coshocton, Ohio, plant of Universal Cyclops Steel Co. is one of the most completely modern plants in the country.

Among its advanced equipment, the company uses a Pangborn Rotoblast Descaling Machine in a 659 ft. fully-automated line. This machine—requiring no operator—continuously blast cleans two strands of steel simultaneously at speeds up to 80 LFM. To provide a high degree of flexibility, it has individual strand control and permits changing the position of Rotoblast wheels at the touch of a button. Abrasive velocity and volume are also variable and two-speed motors give a choice of 50 h.p. at 1200 RPMs or 75 h.p. at 1800 RPMs, depending on type and thickness of work.

Rotoblast's efficiency and adaptability to individual descaling problems have proved the value of Rotoblast to Universal Cyclops. They can in *your* plant. For more information, talk to the Pangborn man in your area or write PANGBORN CORPORATION, 4400 Pangborn Blvd., Hagerstown, Md. *Manufacturers of Blast Cleaning and Dust Control Equipment—Rotoblast Steel Shot and Grit.*

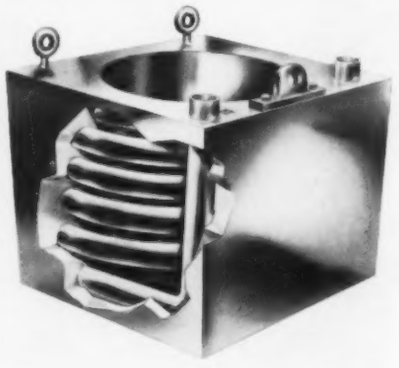
Pangborn

Cleans it fast with ROTOBLAST®

the sand and abrasive mixture into a 75,000-lb-per-hour capacity air-wash separator where all sand and fine particles of abrasive are removed. Fourth, as an extra precaution all air washed abrasive is then passed through final screening. The clean, usable abrasive is then passed to a storage hopper for reuse. Offered as optional equipment is a special 150,000-pph separator for use where extremely heavy sand loads are prevalent.

ROOF COOLERS

△ Roof coolers blocks for entry of oxygen lances into open hearths are now supplied by Philadelphia Bronze & Brass Corp. in a new design that gives maximum life and freedom from corrosion. Superior cooling efficiency is obtained by unique construction in which high



conductivity copper tubing is cast directly into a high conductivity copper block.

Cast copper is electrolytic grade, having a certified minimum conductivity of 95 per cent I.A.C.S. Use of selected materials gives maximum heat transfer and assures resistance to corrosive effects of steel mill water.

ROLLER BEARINGS

△ A new series of channel-shaped outer ring roller bearings introduced by the Torrington Co. features a new, patented cage design. Utilization of the cage design permits application of the bearings at speeds higher than those attainable with full complement types. Longer and larger rollers in these standard inch-size cage-type roller bearings result in greater capacities than heretofore available. Made in sizes ranging from $\frac{3}{4}$ to 4-in. bore, and designated as series HJ, the bearings may be applied directly to hardened and

SOLID! Section of Roebel bar for 22,000 Volt, 76,000 KVA turbogenerator stator.

The outstanding insulation for high voltage coils

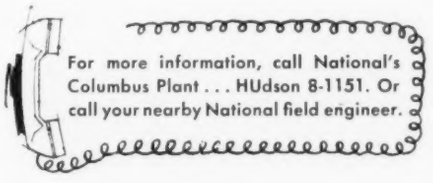
NECCOBOND...solid insulation bonded to the copper provides longer life, greater strength and stability

In NECCOBOND, National has developed a complete insulation system, using mica, glass and a special impregnant. Its particular advantages for high voltage coils are:

- Exceptional thermal stability.
- Optimum mechanical and electrical properties.
- High heat conductivity.

NECCOBOND is based on time-proven insulating materials – mica and glass. These are welded by a special impregnant into a tenaciously bonded, resilient, voidless insulation wall. A unique method of fabrication assures homogeneous insulation.

When replacing high voltage coils, investigate the long term savings with NECCOBOND. You'll find our advice impartial–we offer all types of insulation.



McGRAW EDISON

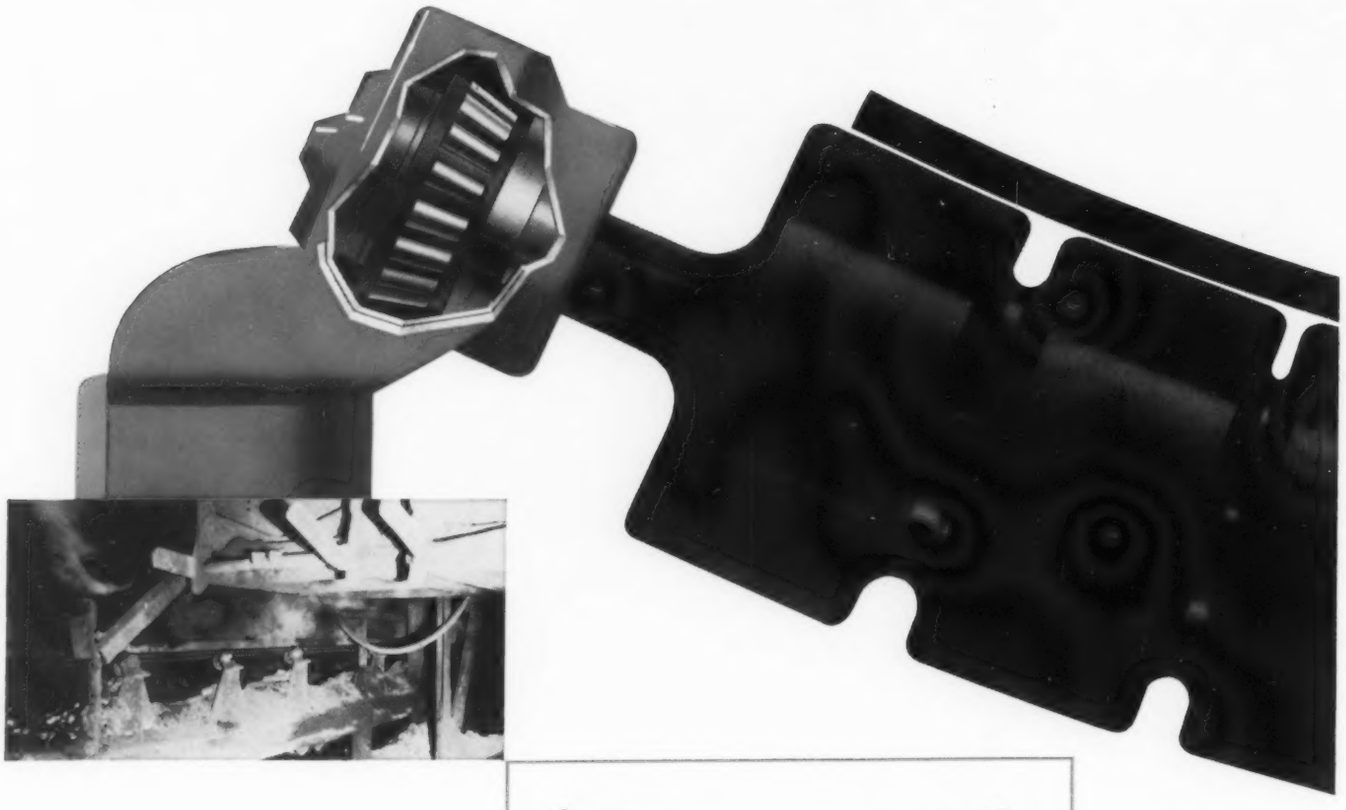
National Electric Coil

DIVISION OF McGRAW-EDISON COMPANY

COLUMBUS 16, OHIO

ELECTRICAL ENGINEERS • MANUFACTURERS OF ELECTRICAL COILS, INSULATION, LIFTING MAGNETS
REDESIGNING AND REPAIRING OF ROTATING ELECTRICAL MACHINES

Bearing Location is the Key to Long Service Life



JOY LIMBEROLLER® CONVEYOR IDLERS

Joy Limberoller Conveyor Idlers give many times the normal service life, because the two bearings rest in slots in the support brackets—well away from spillage. On conveyor lines carrying ore, limestone, and other abrasive materials, Limberollers have given more than ten times the service life of steel idlers.

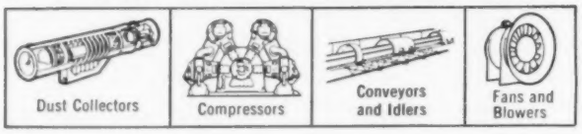
Limberoller Idlers consist of a neoprene coated wire rope to which are moulded neoprene discs. The ends of the rope turn in sealed bearings. This design not only eliminates clogging and freezing of the bearings, but also makes the idlers easy to service—they can be replaced while the belt is moving.

Limberollers are economical, not only because of long service life, but also because they can be spaced further apart than steel idlers. They are corrosion and flame resistant, self-cleaning, and eliminate the "bump" typical of steel idlers.

For complete details, write for Bulletin 359-68.

359-11-803

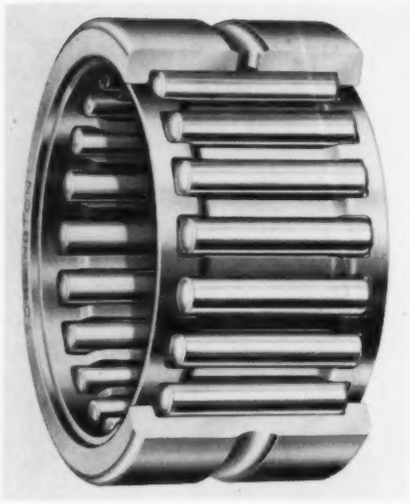
EQUIPMENT FOR ALL INDUSTRY



JOY

Joy Manufacturing Company
Oliver Building, Pittsburgh 22, Pa.

In Canada: Joy Manufacturing Company (Canada) Limited, Galt, Ontario



ground shafts or used with inner rings which are also available. Boundary dimensions conform to standard AFBMA series NAA and NAB, and the bearings are interchangeable with needle bearings made to these standards.

The distinctive one-piece cage design separates roller guiding and roller retaining functions by employing a cage bar depressed within the roller pitch circle. Roller guidance takes place at the ends of the rollers, and at the pitch line where guidance is most effectively accomplished with minimum friction. Rollers are retained by the middle portion of the cage bar which is always out of contact with the rollers during operation, preventing needless wiping away of lubricant common with ordinary cylindrical cages. Lubricant circulates freely through the bearing.

Rollers have controlled contour profiles—the ends being a few hundred-thousandths of an inch less in diameter than the middle. This end relief design prevents stress concentration at the ends of the rollers and insures uniform load distribution.

The new design gives extremely long service life and combines highly effective roller guidance, minimum internal friction and generous provisions for lubrication to allow operation at higher speeds.

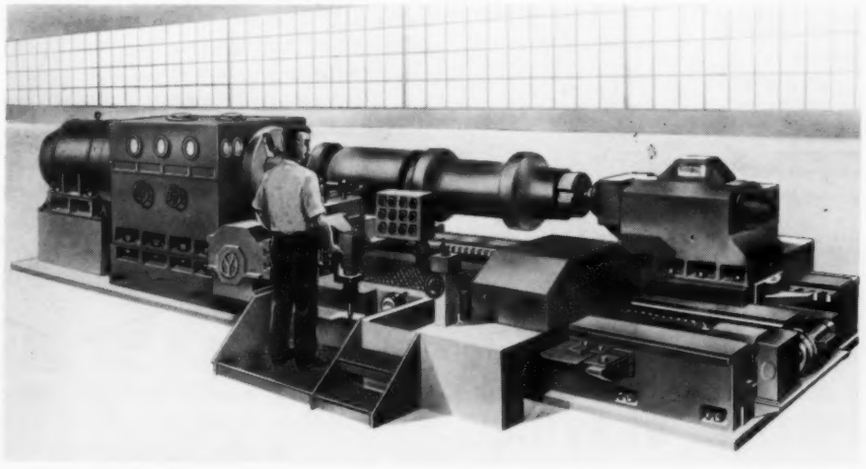
STRAIGHTENERS

△ New, heavy-duty straightening machines, designed particularly for precision straightening of large diameter bars, are offered by Sutton Engineering Co. Featured is fast, high-production straightening of hot-rolled steel bars and alloy heat-treated bars, including drill collar stock.

Two large-size machines, known as the Sutton 5BC are now being built for two different steel plants for straightening bars of from 2 to 10 in. diam. The 5BC will be one of the world's largest bar straighteners. Its design will be similar to the 3BC

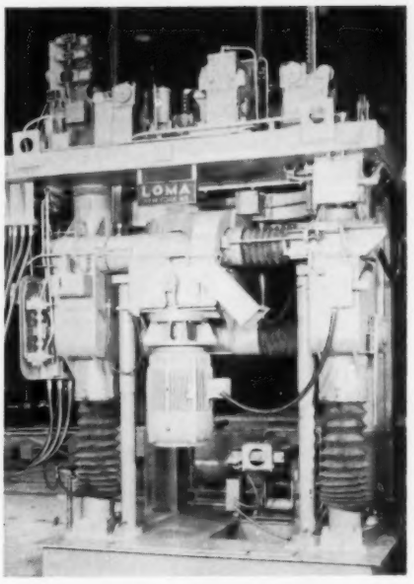
AUTOMATIC CONTOUR ROLL LATHES

This sketch, made during construction, shows the typical design of the Youngstown Foundry & Machine Co.'s contour roll lathes. Automatically controlled, hydraulic or electric tracers, which are templet or numerically controlled assure smooth operation, fine finish and extremely close tolerances. Tool post and carriage are designed for use of either carbide-tipped tools or regular roll turning tools. Higher headstock speeds can be furnished to accommodate ceramic tooling. The heavy duty spring-loaded tailstock avoids overloading of bearings with load indicator.



LOMA

CONTINUOUS CASTING MACHINES



FOR THE PRODUCTION OF

- ROLLING MILL SLABS
- EXTRUSION BILLETS
- PIERCING BILLETS
- WIRE BARS

Improve cast shop operating efficiency and metallurgical product quality with a LOMA fully continuous casting machine. The equipment handles copper in all its various forms — from phosphor de-oxidized and oxygen-free to fire refined and tough pitch. The basic design of the machine also lends itself to the casting of brasses, bronzes, aluminum and magnesium alloys. The shapes produced on the unit include round piercing and extrusion billets, square wire bars and rectangular slabs.

Our standard line of equipment includes:

- Casting Machines and Molds
- Saws and Cut-off Machinery
- Hot and Cold Rolling Mills
- Rod and Tube Draw Benches
- Roller and Stretcher Levellers
- Air and Hydraulic Tube Testers

LOMA

MACHINE MFG. CO., INC.

114 East 32nd Street

New York 16, N. Y.

machine. Both sizes, despite large capacities and high-production speeds, are motorized and remotely controlled for one-man operation.

The Sutton 5-roll principle of straightening is employed. A central pressure roll is located between two sets of opposed rolls, each set having one driven roll and one idler roll. As the straightening load is distributed over three points, maximum work per pass is accomplished resulting in quality end-to-end straightening.

All controls are accessible; all major adjustments are motorized and are operated from a control pulpit. Indicating dials showing roll adjustments are clearly visible to the operator, who is able also to observe the straightening operation in the pass line at all times.

A heavy-duty gear drive incorporates Sutton Universal Joints for long, trouble-free life and an enclosed, one-shot central lubrication system protects all points which require frequent lubrication. Antifriction bearings are used throughout. Compact in design for such heavy-duty equipment, the new Sutton straighteners, including the drive, occupy a minimum of floor space. They can be installed directly in mill lines and can be furnished complete with entry and exit tables.

Sutton heavy-duty 5-roll straighteners are part of a complete line of 2, 5 and 7-roll straighteners for all sizes of bars and tubes in all modern metals.

SENSING GOVERNOR

△ A universal electric governor (Model EFG) for use on diesel engines, gasoline engines, steam turbines and gas turbines is available from the Westinghouse Electric Corp. The new unit is designed for constant speed control over a 10 per cent range in 400 cycle service, and over a 30 per cent range in 50/60 cycle service.

The sensitivity and response characteristics of the governor are measured in milliseconds. The frequency circuit operates within three milliseconds of the time that even the smallest speed change occurs. Full movement of the throttle from closed position to open position (and vice versa) is accomplished in 0.035 second.

In addition, the high sensitivity of the EFG governor improves the speed regulation of slower speed engines under 720 rpm.

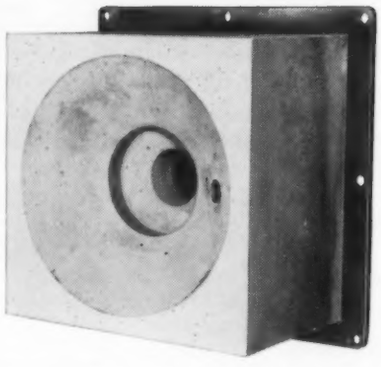
Another important advance in the new unit is the development of a transducer (differential transformer) element which replaces the wire-wound feed-back potentiometer. With no exposed wires or forced rubbing contact, this element gives increased service life.

Some of the features of the model EFG electric governor include standard design universally adaptable to prime movers of any make or model; isochronous in single unit or parallel units operation; independent of throttle linearity; independent of load balance per phase and load power factor; and maintaining constant speed to full capability of the engine to carry the load, including overload.

The electric governor does not require motor operation of the frequency reference potentiometer for remote control. A manual frequency reference potentiometer can be installed as far as 250 ft from the electric control for remote adjusting of frequency output.

Furthermore, the model EFG governor does not require an accurate and sensitive speed drive accessory in the engine, as do conventional hydraulic governors.

Focus High Heat



The

BLOOM

HTR

BURNER

The Bloom High Thermal Release Burner can be located in a furnace roof or wall to give the operator the temperature he needs for a given area. Maintenance on this burner is minimized, since alloy or cast iron parts aren't exposed to high temperature.

Applications include:

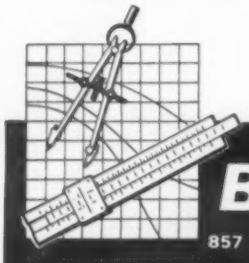
Tube Upsetting

Continuous Strip Pre-Heating, Annealing, Coating, and Drying

Batch type Forging

Aluminum Chip Melting

Meta-Silicate Melting



BLOOM ENGINEERING COMPANY, INC.

857 WEST NORTH AVENUE • PITTSBURGH 33, PENNSYLVANIA

ENGINEERING • EQUIPMENT • SERVICE

A GOOD START TO A BETTER FINISH

MIDVAC

*Micro Lustre**

VACUUM MELTED FINISHING ROLLS

Here are the rolls which have cut repolishing time in half... lasted 33% to 50% longer on the mill between grinds... produced a finer finish using same polishing procedure as competitive rolls. They are made from consumable electrode, vacuum arc melted Midvac Steels with super uniformity of fine grain structure... and have maximum freedom from defects and non-metallic inclusions. The exclusive Micro Lustre* finish of these rolls assures rolling free of surface imperfections... quicker repolishing... longer trouble-free service between grinds.

If you are rolling stainless steel, aluminum foil, brass, precious metals or any other high finish product specify Midvac Rolls for longer runs and lower operating costs. Write for complete data on these rolls and the new roll hardness selector chart.

MIDVALE-HEPPENSTALL COMPANY
NICETOWN, PHILADELPHIA, PA.
Subsidiary of HEPPENSTALL COMPANY, Pittsburgh, Pa.

MH

Midvac Rolls

*Trademark

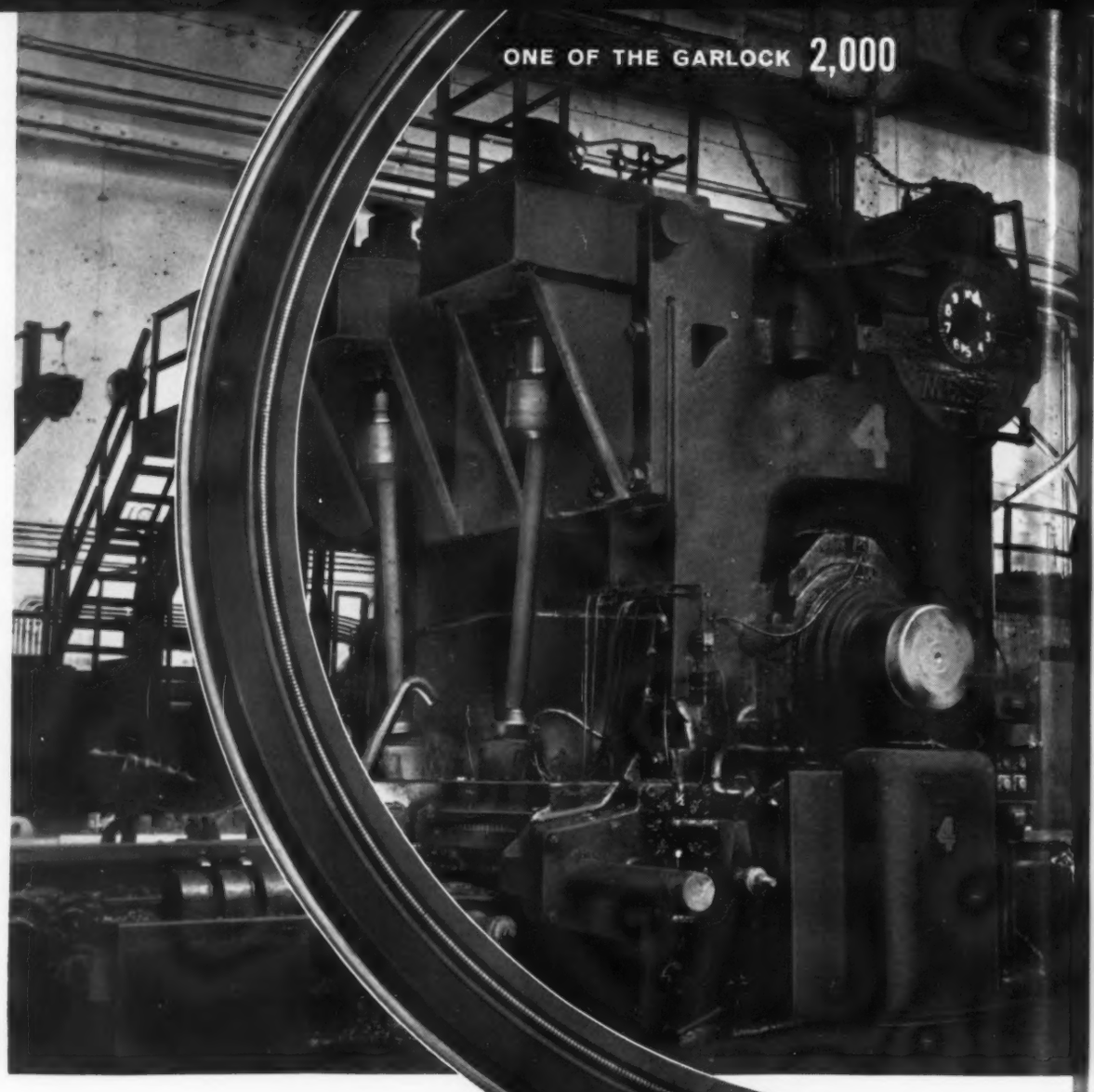
Model 64 assembled KLOZURE for back-up and work rolls. Designed for large shafts, severe service.

Model 82 bonded KLOZURE for back-up and work rolls, normal to high speeds. Comes as large as 44" diameter.

Model 21 or 23 Split- KLOZURE for installation without disassembly of equipment. Medium-speed service.

Model 142 face type KLOZURE for mill rolls. Designed to seal surfaces perpendicular in shaft.

Model 53 assembled KLOZURE for table rolls, normal to high speeds. Withstands temperatures to 250° F.



All around the mill . . .

Garlock KLOZURE* Oil Seals Assure Smooth, Dependable Operation

ON ALL PARTS OF A STEEL MILL, KLOZURE Oil Seals prevent leakage of vital bearing lubrication while protecting the bearings themselves from dirt, slag, scale, and spray. There's a KLOZURE design for *every* job, no matter how difficult.

MODEL 142, for example, keeps water splash and scale out of bearings at the shoulder of a mill roll. Model 53 is recommended for table rolls; Models 64 and 82 are applied for protecting bearings on back-up and work rolls. Where equipment can't be dismantled easily, Model 21 or 23 Split-KLOZURES are the choice.

ALL KLOZURES are oil and grease resistant . . . impervious to water, mild acids, alkalies . . . non-abrasive . . . withstand temperatures from −40°F to +250°F. For extreme conditions, Garlock furnishes sealing elements resistant to practically any fluid, and serviceable as high as +500°F.

KLOZURE Oil Seals are another part of the Garlock 2,000 . . . two thousand different styles of packings, gaskets, and seals for every need. Call your local Garlock representative, or write for Catalog 20.

*Registered Trademark

THE GARLOCK PACKING COMPANY, Palmyra, N. Y.

For Prompt Service, contact one of our 26 sales offices and warehouses throughout the U.S. and Canada.

GARLOCK

Packings, Gaskets, Oil Seals, Mechanical Seals, Molded and Extruded Rubber, Plastic Products

Canadian Division: The Garlock Packing Co. of Canada Ltd.

Plastics Division: United States Gasket Company

FLYING BILLET SHEAR

△ A new 18-in. billet mill flying shear, engineered and built by Birdsboro Steel Foundry and Machine Co., has been installed at the Pittsburgh Steel Co., Monessen, Pa., plant.

The shear has cut up to $1\frac{13}{16}$ in. square billets at speeds up to 600 fpm. It is designed to handle billets up to $2\frac{1}{2}$ in. square. Through use of a two-throw crank, the top and bottom knives are given an up-and-down-cut shearing action, which assures that the bar will have no hooked ends after shearing.

To eliminate the requirement for expensive electrical drive equipment, the shear is powered by two variable speed, direct current motors which run continuously. Each motor turns a flywheel through a "V" belt drive. Connected to each flywheel is an air clutch, and each flywheel and air clutch in turn is mounted on a gear pinion meshing with a bull gear keyed to the end of a crank shaft.

Two crank shafts are provided, one with a double throw for working the knives and the other with a single throw for moving the knife head with the bar. The air clutches are electrically timed to work the cranks in the proper sequence when a billet is being sheared.

The shear frame is set on ways and the entire shear may be moved out of the mill line by a motor-operated screw drive. When the shear is in operation, the frame is held down by hydraulically-operated clamps.

BUS DUCT

△ A bus duct to distribute high-frequency power with minimum voltage drop and with little change in phase relationship is now available from the Westinghouse Electric Corp.

Maximum voltage drop at 400 cycles per second is 1.28 volts per 100 ft, and the duct will operate with high efficiency at frequencies up to 1000 cycles per second. Power at even higher frequencies can be successfully distributed with the new bus duct.

Nearly perfect phase relationship and wave form are maintained since individual conductors in the four-channel rigid aluminum housing are continually transposed and ro-

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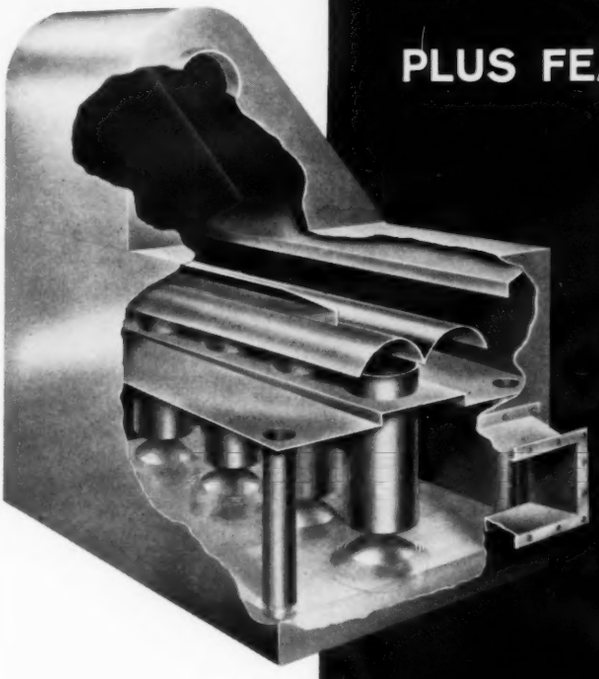
This unique unit presents an entirely new concept in wet collection. The unit offers a wide range of construction features and methods of dust disposal. The new scrubber forces dynamic dust-liquid contact to insure high collection efficiencies.



PLUS FEATURES

- High volume low space requirements
- High efficiency at low draft loss
- No moving parts
- Minimum water consumption
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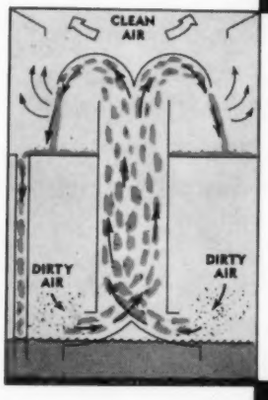
- Custom designs for special applications



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tated while the housing grounds stray radio frequencies.

The cost of the new bus duct is considerably less than for conduit and cable, and space required for installation is also reduced. Standard fittings such as elbows, tees and flanges are available. Four openings are provided in each ten-foot section of duct to take off power through standard "EH" frame circuit breaker plug-in units. The bus duct and associated equipment have been designed to provide a flexible, centralized power distribution system.

PLATING PROCESS

△ Hanson-Van Winkle-Munning Co. announces the availability of a new bright copper cyanide process. Trade name of the process is "Copper-Lume."

The process offers the following characteristics: smooth, bright deposits over an extremely wide temperature and current density range; good metal distribution; solution simple to operate and control. Deposits can be buffed with ease, if required.

Bath constituents can include either potassium salts, a mixture of potassium and sodium salts or sodium cyanide only. The deposits do not require activation before subsequent nickel plating.

TEMPERATURE INDICATOR

△ "Thermomelt" is the name of a new product line developed by the Markal Co. for the metalworking industry and many other fields where heat is used.

It is a precision temperature indicator designed to tell metallurgist, engineer and metalworker when a surface has reached a specific temperature. Available in stick, pellet and liquid form, it is provided in a wide choice of Fahrenheit ratings from 113 to 2000, which according to the manufacturer will cover all requirements in the heat-treating and heat-processing fields.

The metal surface is marked with the stick or liquid, or a pellet is placed on the surface. When the surface reaches the wanted temperature, the "Thermomelt" mark (or the pellet) quickly liquefies.

The stick comes in a metal holder, which enables the user to dispense the stick as needed and also prevents breakage and consequent loss of part of the stick. The liquid is packaged in a glass bottle with a brush dispenser in the cap, while the pellets are packaged 20 to a plastic tube.

Book Reviews

"National Electrical Code, 1959" (ASA CI-1959 UDC 614,825) has been approved as an American Standard by the American Standards Association and has been recently published by the National Fire Protection Association, 60 Batterymarch Street, Boston 10, Mass. The book contains 528 pages, 4½ x 7 in., is bound in heavy paper (available from either the ASA, Dept. PR 100, 70 East 45th St., New York 17, N. Y. or from the publisher at $1.00 per copy). This 1959 revision not only includes many changes in substance, but also a new numbering system. Because of this new system, an

(*Please turn to page 266*)

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To keep abreast of this trend, Sharon Steel Corporation recently built a complete new Melt Shop at its Roemer Works in Farrel, Pennsylvania, and installed the large Heroult Electric Furnace shown above.

This 20′ diameter furnace turns out 90-ton heats of top-quality stainless in less than 8 hours. Space has been provided for a second Heroult when it is needed.

Moreover, electric furnaces are proving to be more efficient and economical in producing most *any* grade of steel in large or small heats. This is because electric furnace operations require a smaller investment, usually reduce both power and charging costs and produce a more uniform product.

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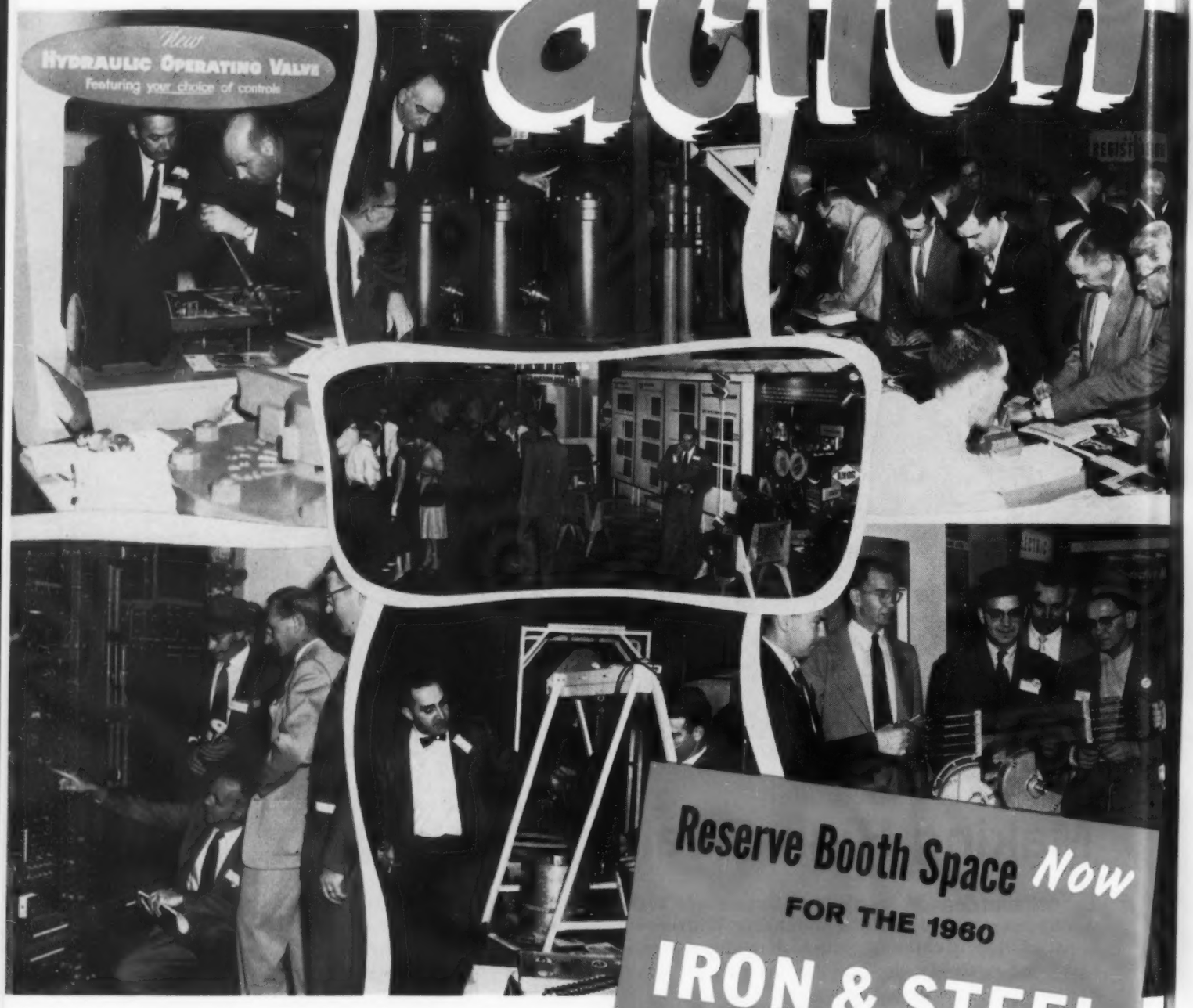

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1 The entry friction guides are rigidly clamped into the guide box. They are intended to lead the oval to the groove in the roller, to protect the rollers against overloading, and to straighten bent rods.
The groove in the entry guides is made about 1/8" wider than the oval.

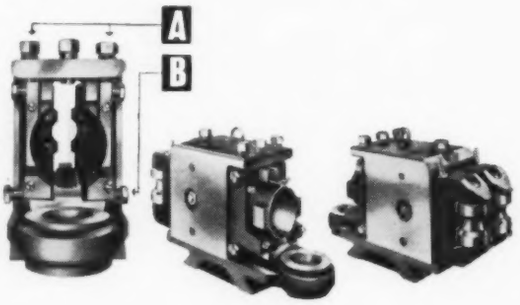
2 The rollers are mounted on leaf springs, which can be adjusted by means of the screws "B", and hold the oval steadily even if there should be some slight variation in the thickness of the oval.

3 If the thickness of the oval should vary, the springs of both rollers yield an equal amount, so that the oval remains in the centre of the groove.

4 To tilt the oval, the screws "A" are adjusted. One roller will then be lifted as much as the other is lowered.

5 As the oval is held very rigidly, the leader oval for wire rod may be thick, unless other circumstances call for a thinner oval.

6 The roller guide assemblies are narrow, and all screws that require adjustment during rolling are accessible from the front of the mill. No lateral space outside the guide box is therefore required for gaining access to the set screws, and the guide box assembly can thus be located close to the mill housing.



7 As the groove in the entry guides is wide and nothing but rolling friction acts on the oval, the latter is very easily introduced into the pass, and there is practically no risk of scratching the bar.

8 The roller guide may be used not only for leader and drawing oval passes but also for edging flats as well as for rolling squares, hexagons, octagons and various other sections, for instance in reduction passes for hexagon. It is suitable for all types of rolling mill. An important advantage is that the roller guide enables repeaters to be used in rolling plump leader-ovals.

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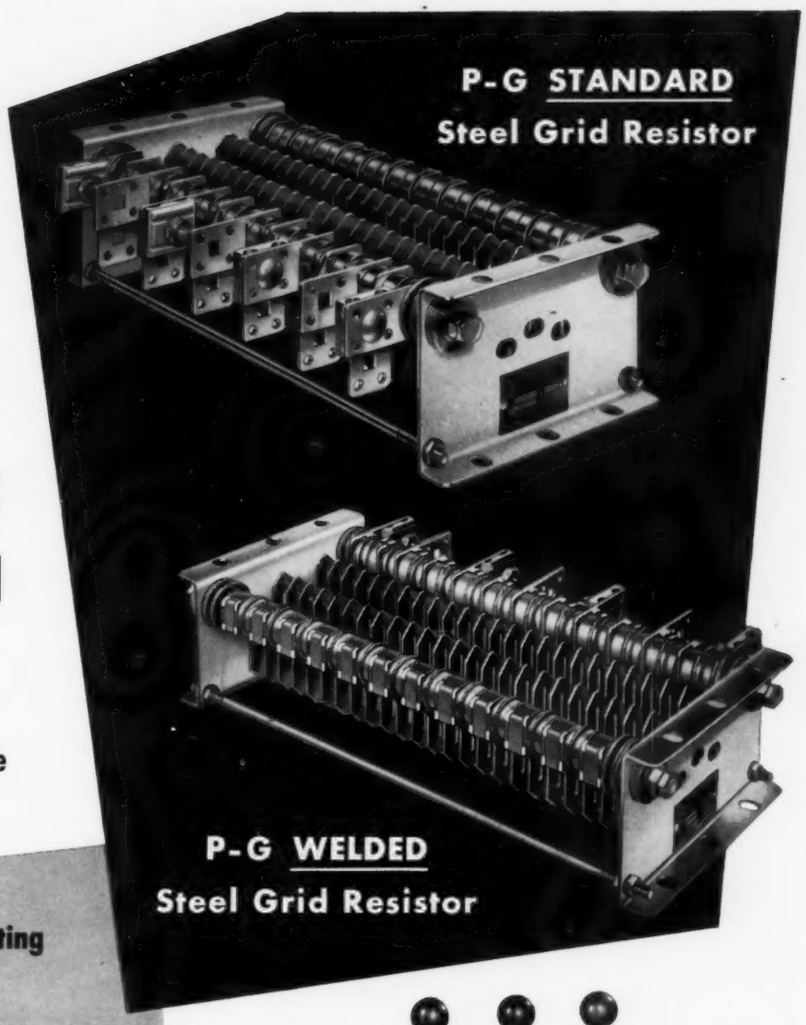

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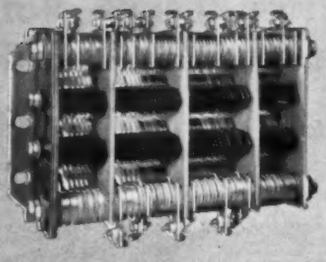

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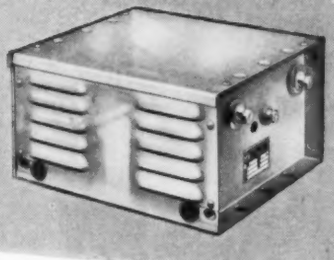

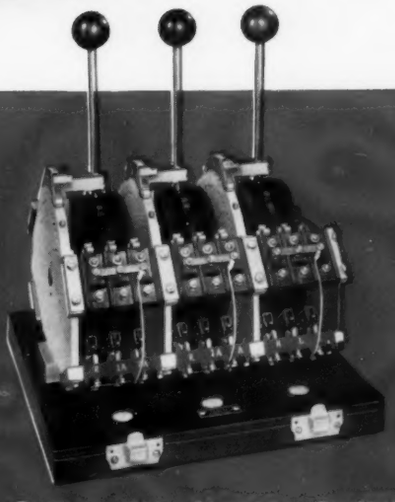

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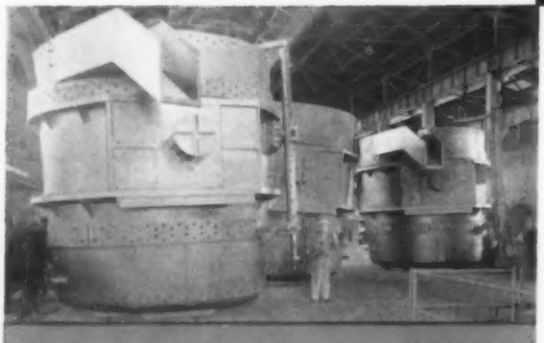

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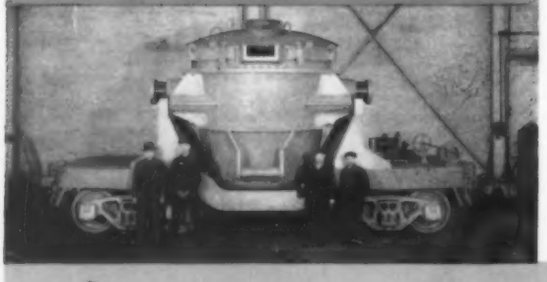

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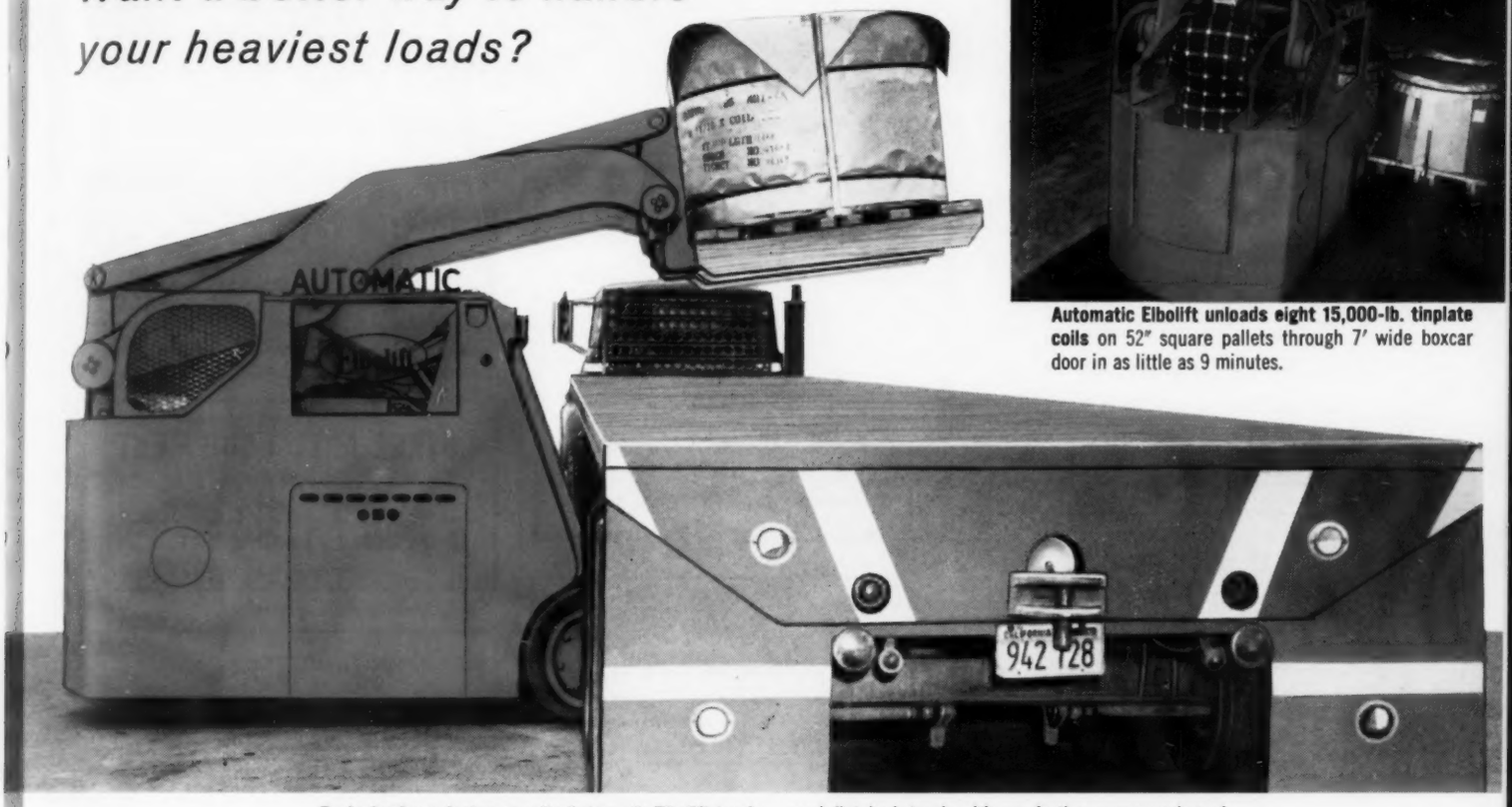

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Book Reviews

(Continued from page 256)

appendix is included providing cross references with the 1956 edition. Sections which have been revised since then are indicated in bold face in this appendix. The code sets up minimum requirements necessary for safety in the use of electricity for light, heat, power, radio, signals, etc., primarily in buildings. This edition replaces all previous editions and is widely used by regulatory bodies.

"**Handbook of Heavy Construction,**" prepared by 36 noted specialists and edited by Frank W. Stubbs, Jr., has recently been published by McGraw-Hill Book Co., 327 West 41st Street, New York 36, N. Y. The book contains 1040 pages, 6 x 9 in., is cloth bound and sells for $18.50. The book offers a convenient reference to the methods, data and working information needed in all branches of heavy construction, and offers quick answers to a wide range of practical problems concerned with earth-moving, concrete, steel erection, highways, foundations and other areas of the field. It supplies expert guidance in estimating the requirements of a construction job, performing major field operations, operating and maintaining equipment and making best use of modern materials. It provides tables of data for figuring the costs of operating and owning equipment, output of equipment, economical use of materials and other cost factors. Included in the book are chapters on excavators, tunnels, explosives, dewatering, pneumatically applied concrete, precast and prestressed concrete, intrusion grouting, electric-arc welding, timber construction, bituminous pavements, pipelines cofferdams and caissons, pile driving, river diversion, construction contracts, safety, contractor's organization and other topics. These are discussed in practical terms, with particular stress on cost, materials, procedures, equipment, schedules, controls, redesign and operation. It enables everyone concerned with construction to fully investigate all problems on a project, particularly considering present higher costs, faster schedules and complexity of operations.

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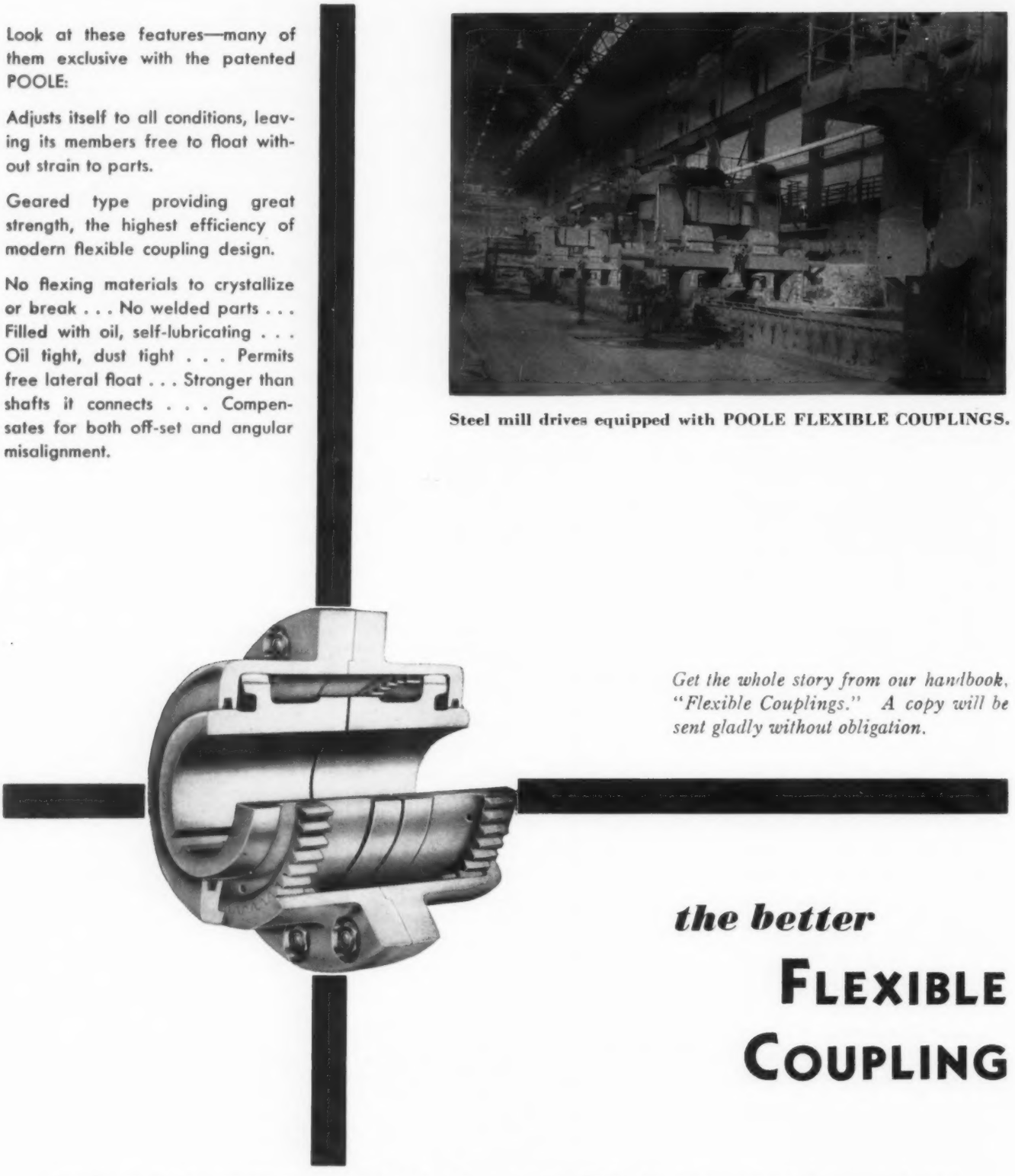

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